M121

IMPORTANT NOTE CONCERNING THE FOLLOWING PAGES

THE PAGES WHICH FOLLOW HAVE BEEN FILMED TWICE IN ORDER TO OBTAIN THE BEST REPRODUCTIVE QUALITY

USERS SHOULD CONSULT ALL THE PAGES REPRODUCED ON THE FICHE IN ORDER TO OBTAIN A COMPLETE READING OF THE TEXT.

REMARQUE IMPORTANTE CONCERNANT LES PAGES QUI SUIVENT

LES PAGES SUIVANTES ONT ÉTÉ REPRODUITES EN DOUBLE AFIN D'AMÉLIORER LA QUALITÉ DE REPRODUCTION

LES UTILISATEURS DOIVENT CONSULTER TOUTES LES PAGES REPRODUITES SUR LA FICHE AFIN D'OBTENIR LA LECTURE DU TEXTE INTÉGRAL

Micromedia
ProQuest

789 East Eisenhower Parkway
PO Box 1346
Ann Arbor, MI 48106-1346 USA
toll free: 1-800-521-0600
fax: (734) 997-4247
web: www.micromedia.ca

Concentrations of Metals and Other Elements in Surface Soils of Flin Flon, Manitoba and Creighton, Saskatchewan, 2006

July 2007

Report No. 2007-01

Manitoba

Report No. 2007-01
July 2007

Concentrations of Metals and Other Elements in Surface Soils of Flin Flon, Manitoba and Creighton, Saskatchewan, 2006

Manitoba

Synopsis

Manitoba Conservation conducted sampling in August 2006 to determine the concentration and potential distribution of metals and other elements in the surface soils of Flin Flon, Manitoba (includes Channing) and neighbouring Creighton, Saskatchewan.

Sample sites included publicly accessible lands such as boulevards, parks/playgrounds, school yards, vacant lots and undeveloped parcels of land in each community. A total of 108 sites were sampled, including 93 sites in Flin Flon, 13 sites in Creighton, a site at Bakers Narrows Provincial Park and a site in Cranberry Portage. The survey was designed and funded by Manitoba Conservation, with assistance from the Saskatchewan government.

The provincial government has been monitoring air and water quality periodically in the Flin Flon area since the late 70's. This study is another step in assessing and protecting the well-being of residents and the local environment.

What were the results of the survey?

Concentrations of several elements, including arsenic, cadmium, lead and mercury, were above recommended Canadian Council of Ministers of the Environment (CCME) soil quality guidelines for human health at a number of sites across the study area. These elements are known to be part of the past and present atmospheric emissions from the Hudson Bay Mining and Smelting Co., Limited (HBM&S) smelter complex in operation for more than 75 years.

The highest concentrations were usually found on undeveloped parcels of land. This may be because smelter particulates have been deposited to the soil surface over a longer period compared to boulevards and parks/playgrounds that have been landscaped more recently. In Flin Flon this included sites in the downtown and adjacent residential areas south of the smelter, as well as in undeveloped areas around the north basin of Ross Lake. The highest concentrations in Creighton were found in the northeast part of the community south of the tailings management area.

What do the results mean?

Given that levels of certain metals and other elements are above the CCME guidelines, HBM&S and the governments of Manitoba and Saskatchewan are undertaking a human health risk assessment with the guidance of a local community advisory committee that will be established.

The CCME guidelines are conservative and based on a scenario of prolonged, year-round exposure for the most vulnerable individuals. A preliminary review of the results suggests that the risk to human health is most likely low, but a more comprehensive human health risk assessment is needed to better and more fully determine this risk.

Private residential yards were not sampled to any extent in this survey. However, since landscaping and maintenance practices are similar, private lawns and yards may have element concentrations comparable to parks/playgrounds and school yards in the general vicinity. The climate of Flin Flon and Creighton likely reduces exposure since the soils in the region are usually covered with snow for a portion of the year.

Studies conducted around other Canadian mining and smelter operations with similar or higher levels of metals and arsenic in the soil have not shown any expected immediate risk to human health. In Sudbury, an ecological and human health risk assessment is currently underway.

The risk assessment will look at the potential health effects of being exposed to metals and other elements in the Flin Flon area. It will assess the likelihood of exposure, the type and severity of risk and what could be done to address any issues identified by the assessment. Analysis of soil samples provides one piece of information to show what is in the environment in the Flin Flon area. Information on metals and other elements in water, air and food along with soil are needed to provide an overall picture of how metals and elements may affect residents. Additional samples will be collected and analyzed to fill data gaps or address incomplete information.

How can you reduce your exposure?

There are a number of steps that may be taken to reduce exposure to metals and other elements in soil including:

- Wash hands after outside activities such as playing and gardening, and before handling and eating food. Wear gloves when working outside.
- Keep children's toys and play areas clean. Remind children to keep their hands out of their mouths when playing outside.
- Remove shoes and boots at the door.
- Use wet-mopping and wet-wiping when cleaning dust in the home, as vacuuming and sweeping can increase dust levels.
- Ensure that the heat ducts and furnace filters are cleaned regularly.
- Brush pets often and outside.
- Wash locally grown garden produce and peel root crops before eating.

What are the next steps?

Hudson Bay Mining & Smelting Co., Limited, the Manitoba and Saskatchewan governments and a soon-to-be-established community advisory committee will therefore undertake a human health risk assessment. Further details will be provided in the months ahead.

In cooperation with Healthy Flin Flon, planning is underway for a public presentation and discussion of the results of the soil survey in Flin Flon.

Manitoba recognizes that programs such as the Flin Flin/Creighton Green Project are improving the soils and natural ecosystems in the Flin Flon area. Government support to this program will be continued and enhanced.

Additional samples will be collected and analyzed to fill data gaps or address incomplete information.

Who should you contact for more information on this report?

Please contact Manitoba Government Inquiry at 1-866-626-4862 or go to the Manitoba Conservation website at: http://www.gov.mb.ca/conservation/wildlife/managing/mon_eco.html

Manitoba Conservation. 2007. *Concentrations of Metals and Other Elements in Surface Soils of Flin Flon, Manitoba and Creighton, Saskatchewan, 2006.* Manitoba Conservation. Report No. 2007-01, Winnipeg, MB. 64 pp.

Summary

Numerous studies and monitoring programs have investigated the effects of atmospheric emissions from the Hudson Bay Mining & Smelting (HBM&S) complex on the environment in the vicinity of the city of Flin Flon in west-central Manitoba. This has included assessing the concentrations and effects of metals and other elements of concern in forest vegetation and soils, in the snow pack, and in locally grown vegetables. No detailed soil sampling has been conducted to determine levels of metals and other elements in urban surface soils.

A study was designed and conducted by Manitoba Conservation in August 2006 to determine the concentration and potential distribution of metals and other elements in the surface soils of Flin Flon, MB and neighbouring Creighton, SK. The top 2.5 cm of soil was sampled at 93 sites in Flin Flon (includes Channing), 13 sites in Creighton, a site at Bakers Narrows Provincial Park, and a site in Cranberry Portage. The latter two sites were chosen to represent minimally impacted and non-impacted conditions, respectively. Sites included publicly accessible lands such as boulevards, parks/playgrounds, school yards, vacant lots, and undeveloped parcels of land within each community.

Concentrations of antimony (Sb), arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), molybdenum (Mo), selenium (Se), silver (Ag), sulphur (S), thallium (Tl), and zinc (Zn) were elevated across much of the study area relative to the concentrations at the sample site in Cranberry Portage, and were also highly positively inter-correlated, suggesting that they originated from a common source. These elements are known or suspected constituents of past and present atmospheric emissions from the HBM&S smelter complex. The highest concentrations of these elements were usually associated with sites located on undeveloped parcels of land and sites located in older neighbourhoods that are relatively close to the smelter complex. Soils at these sites have likely been exposed to atmospheric emissions for a longer period of time compared to more recently developed areas of Flin Flon and Creighton. Interpolation and mapping of the data using GIS showed that in Flin Flon the concentrations of these elements may be highest throughout the downtown core and adjacent residential areas south of the smelter, as well as in undeveloped areas around the north basin of Ross Lake. The highest concentrations in Creighton soils were found in the northeast portion of the community south of the tailings management area.

The results were compared to the CCME soil quality guidelines and interim environmental quality criteria for residential/parkland soils. Concentrations of As, Cd, Cu, Pb, and Hg exceeded CCME soil quality guidelines for the protection of human health at a high proportion of the sites, while concentrations of Se and Tl exceeded their respective guidelines at a smaller number of sites. The soil guideline for Zn was exceeded at almost all of the sites but this guideline is for environmental health protection and not human health protection. Concentrations of Sb, Mo, Ag, and S were assessed using CCME interim environmental quality criteria because CCME soil quality guidelines for these elements have not been established. Although elevated across much of the study area relative to the sites at Bakers Narrows and

Cranberry Portage, none of these elements exceeded existing interim environmental quality criteria for residential/parkland soils.

Manitoba Conservation. 2007. *Concentrations of Metals and Other Elements in Surface Soils of Flin Flon, Manitoba and Creighton, Saskatchewan, 2006.* Winnipeg (Manitoba), Manitoba Conservation. Rapport n° 2007-01, 2007, 64 pp.

Résumé

Bon nombre d'études et de programmes de surveillance ont examiné les effets des émissions atmosphériques provenant du complexe de la Hudson Bay Mining & Smelting (HBM&S) sur l'environnement aux environs de la ville de Flin Flon, dans la région du Centre-Ouest du Manitoba. Il s'est agi entre autres de l'évaluation des concentrations et de l'incidence des métaux et des autres éléments néfastes sur la végétation forestière et les sols, sur la couche de neige et sur les légumes produits localement. Aucun échantillonnage de sols détaillé n'a été effectué afin de déterminer les concentrations de métaux et d'autres éléments dans les sols de surface urbains.

Une étude a été conçue et menée par Conservation Manitoba en août 2006 pour établir la concentration et la répartition potentielle des métaux et des autres éléments dans les sols de surface de Flin Flon, au Manitoba, et dans la ville avoisinante de Creighton, en Saskatchewan. Les 2,5 cm supérieurs du sol ont fait l'objet d'un échantillonnage dans 93 emplacements à Flin Flon (y compris à Channing), 13 emplacements à Creighton, un emplacement au Parc provincial de Bakers Narrows et un emplacement à Cranberry Portage. Ces deux derniers emplacements ont été choisis pour représenter les conditions légèrement influencées et les conditions non influencées, respectivement. Parmi les emplacements figuraient des terres accessibles au public, comme des boulevards, des parcs ou des terrains de jeux, des cours d'école, des terrains vagues et des parcelles de terre non exploitées dans chacune des collectivités.

Les concentrations d'antimoine (Sb), d'arsenic (As), de cadmium (Cd), de cuivre (Cu), de plomb (Pb), de mercure (Hg), de molybdène (Mo), de sélénium (Se), d'argent (Ag), de soufre (S), de thallium (Tl) et de zinc (Zn) étaient élevées dans l'ensemble de la zone d'étude en ce qui concerne la concentration à l'emplacement de Cranberry Portage où l'on a prélevé les échantillons et elles avaient également une très grande intercorrélation positive, ce qui faisait croire qu'elles provenaient de la même source. Ces éléments sont des composantes connues ou présumées d'émissions atmosphériques antérieures ou actuelles provenant du complexe de fusion de HBM&S. Les concentrations les plus élevées de ces éléments étaient habituellement associées à des emplacements situés dans des parcelles de terre non exploitées et dans les vieux quartiers assez proches du complexe de fusion. Les sols à ces emplacements ont, selon toute probabilité, été exposés aux émissions atmosphériques pendant une période plus longue par rapport aux zones plus récemment aménagées de Flin Flon et de Creighton. L'interpolation et le mappage des données au moyen du système d'information géographique ont montré qu'à Flin Flon, les concentrations de ces éléments sont peut-être les plus élevées dans tout le cœur du centre-ville et dans les zones résidentielles adjacentes au sud de la fonderie, ainsi que dans les zones non exploitées réparties autour du bassin nord du lac Ross. Les plus grandes concentrations dans les sols de Creighton ont été trouvées dans la partie nord-est de la collectivité située au sud de l'aire de gestion des résidus.

Ces résultats ont été comparés avec les recommandations pour la qualité du sol et les critères provisoires de la qualité de l'environnement du CCME pour les sols résidentiels ou les

sols des forêts-parcs. Les concentrations d'As, de Cd, de Cu, de Pb et de HG dépassaient les recommandations pour la qualité du sol du CCME pour la protection de la santé humaine dans une grande proportion des emplacements, bien que les concentrations de SE et de TI aient dépassé leurs recommandations respectives dans un plus petit nombre d'emplacements. La recommandation pour la qualité des sols en matière de Zn était dépassée dans presque tous les emplacements, mais cette recommandation concerne la protection de la salubrité de l'environnement et non pas la protection de la santé humaine. Les concentrations de SB, de Mo, d'Ag et de S ont été évaluées selon les critères provisoires de la qualité de l'environnement du CCME parce que les recommandations pour la qualité du sol du CCME pour ces éléments n'ont pas été établies. Bien que les concentrations soient élevées dans la plupart de la zone d'étude relative aux emplacements de Bakers Narrows et de Cranberry Portage, aucun de ces éléments ne dépassait les critères provisoires de la qualité de l'environnement pour les sols résidentiels ou les sols des forêts-parcs.

Table of Contents

SYNOPSIS III

SUMMARY VI

RÉSUMÉ VIII

TABLE OF CONTENTS X

LIST OF FIGURES XI

LIST OF TABLES XIII

INTRODUCTION 1

METHODOLOGY 3

Site Selection and Sampling Protocol 3
Laboratory Analysis 8
Data Analysis, Mapping, and Soil Quality Assessment 9

RESULTS 11

General Results 11
Soil Quality Assessment 14
Arsenic (As) *15*
Cadmium (Cd) *18*
Copper (Cu) *21*
Lead (Pb) *24*
Mercury (Hg) *28*
Selenium (Se) *31*
Thallium (Tl) *34*
Zinc (Zn) *37*
Antimony (Sb), Molybdenum (Mo), Silver (Ag), and Sulphur (S) *39*
Other Elements *43*

CONCLUSIONS 44

REFERENCES 48

APPENDIX 51

List of Figures

Figure 1. Map of survey area showing location of sample sites in Flin Flon (including Channing) and Creighton. 5

Figure 2. Map of sample sites in Flin Flon and Creighton with TQ site numbers. 6

Figure 3. Photographs of soil sampling: 7

Figure 4. Selected soil samples showing the range in soil texture from a high proportion of organic material (left) to a sample consisting mainly of sand particles (right). 11

Figure 5. Projected distribution of As in surface soil across the study area based on IDW interpolation of the mean As concentrations at 106 sample sites. 17

Figure 6. Projected distribution of As concentrations above the guideline level of 12 µg/g in surface soil across the study area based on IDW interpolation of the mean As concentrations at 106 sample sites. 18

Figure 7. Projected distribution of Cd in surface soil across the study area based on IDW interpolation of the mean Cd concentrations at 106 sample sites. 20

Figure 8. Projected distribution of Cd concentrations above the guideline level of 14 µg/g in surface soil across the study area based on IDW interpolation of the mean Cd concentrations at 106 sample sites. 21

Figure 9. Projected distribution of Cu in surface soil across the study area based on IDW interpolation of the mean Cu concentrations at 106 sample sites. 23

Figure 10. Projected distribution of Cu concentrations above the guideline level of 1100 µg/g in surface soil across the study area based on IDW interpolation of the mean Cu concentrations at 106 sample sites. 24

Figure 11. Projected distribution of Pb in surface soil across the study area based on IDW interpolation of the mean Pb concentrations at 106 sample sites. 26

Figure 12. Projected distribution of Pb concentrations above the guideline level of 140 µg/g in surface soil across the study area based on IDW interpolation of the mean Pb concentrations at 106 sample sites. 27

Figure 13. Projected distribution of Hg in surface soil across the study area based on IDW interpolation of the mean Hg concentrations at 106 sample sites. 30

Figure 14. Projected distribution of Hg concentrations above the guideline level of 6.6 µg/g in surface soil across the study area based on IDW interpolation of the mean Hg concentrations at 106 sample sites. 31

Figure 15. Projected distribution of Se in surface soil across the study area based on IDW interpolation of the mean Se concentrations at 106 sample sites. 33

Figure 16. Projected distribution of Se concentrations above the guideline level of 28 µg/g in surface soil across the study area based on IDW interpolation of the mean Se concentrations at 106 sample sites. 34

Figure 17. Projected distribution of Tl in surface soil across the study area based on IDW interpolation of the mean Tl concentrations at 106 sample sites.. 36

Figure 18. Projected distribution of Zn in surface soil across the study area based on IDW interpolation of the mean Zn concentrations at 106 sample sites. 39

Figure 19. Projected distribution of S in surface soil across the study area based on IDW interpolation of the mean S concentrations at 106 sample sites. 42

List of Tables

Table 1. Sites sampled in Flin Flon, August, 2006. 4

Table 2. List of elements and other variables analyzed. 8

Table 3. Spearman correlation analysis results. 13

Table 4. Mean concentrations of As in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. 16

Table 5. Mean concentrations of Cd in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. 19

Table 6. Mean concentrations of Cu in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. 22

Table 7. Mean concentrations of Pb in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. 25

Table 8. Mean concentrations of Hg in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. 29

Table 9. Mean concentrations of Se in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. 32

Table 10. Mean concentrations of Tl in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. 35

Table 11. Mean concentrations of Zn in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. 38

Table 12. Mean concentrations of Sb, Mo, Ag, and S in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. 41

Table 13. Number and percentage of sites where concentrations of selected elements exceeded CCME residential/parkland guidelines for human health protection in the Flin Flon and Creighton study area, August 2006. 46

Introduction

The city of Flin Flon is located in west-central Manitoba adjacent to the Manitoba-Saskatchewan border. Hudson Bay Mining and Smelting (HBM&S) has operated a base metal mining and smelting facility in the community since 1930 (McMartin *et al.* 1999). Past and present metal production at the smelter includes copper (Cu), zinc (Zn), and cadmium (Cd), as well as lead (Pb) concentrates and other by-products including gold (Au), silver (Ag), and selenium (Se) (Henderson *et al.* 1998).

Historically, atmospheric emissions from the smelter complex consisted mainly of sulphur dioxide (SO_2) and metal-bearing particles containing Zn, Pb, and iron (Fe). Smaller amounts of Cu, Cd, mercury (Hg), and arsenic (As), and trace amounts of Se and cobalt (Co) have also been present in the emissions (McMartin *et al.* 1999). While these substances still make up the majority of material emitted from the smelter, the actual composition and amount of emissions has varied over time depending, for example, on the grade of ore used and the volume of ore smelted. Atmospheric emissions from the smelter have been discharged via a 251 m stack since 1974. Prior to this a series of shorter smoke stacks ranging from less than 30 m to 69 m tall were used (Winterhalder 2003). Improvements to the smelting process and the recent installation of more effective pollution control devices have helped to reduce the pre-1974 emission levels by approximately 90 % (McMartin *et al.* 1999). As well, construction of the taller smelter stack has helped to disperse emissions a greater distance and thereby reduce the amount of deposition directly on the community.

The Manitoba Government has conducted several monitoring programs since the 1970s to investigate the effects of atmospheric emissions from the HBM&S complex on the natural environment in the region around Flin Flon. These programs include measuring and assessing changes in soil chemistry and vegetation abundance and diversity at long-term monitoring sites in forest stands near Flin Flon (Hogan and Wotton 1980, 1984, Wotton *et al.* 1983, Manitoba Conservation unpublished data from 1998, 2003, and 2004), assessing the deposition of metals and other elements to snow (Hogan and Wotton 1980, Phillips *et al.* 1983, Phillips *et al.* 1986, Manitoba Conservation unpublished data from 2006) and determining the concentration of

metals in blueberry plants and fruits (Wotton 1979, McEachern and Phillips 1983, Manitoba Conservation unpublished data from 2000).

Results from these investigations revealed that:

1. Levels of As, Cd, Cu, Pb, Hg, Se, and Zn are elevated in the surface soil, vegetation, and snow pack in forested areas in the vicinity of the smelter.
2. Deposition amounts of these elements to snow and their concentrations in forest surface soils and vegetation are strongly negatively correlated with distance from the smelter.
3. Deposition amounts of these elements to the snow pack and their concentrations in forest surface soils and vegetation are all positively inter-correlated (correlated with each other).
4. Concentrations of these elements in forest soils and the strength of the inter-correlations and the correlations with distance from the smelter tend to decrease with soil depth.
5. Damage to forest vegetation, particularly mosses and lichens, is evident close to the smelter, but decreases with distance from the smelter.

These results are indicative of atmospheric deposition from a common source, and support the contention that past and present releases from the HBM&S complex are responsible for the elevated levels of certain elements in the environment around Flin Flon. Based on these data it was believed that As, Cd, Cu, Pb, Hg, Se, and Zn were probably also elevated in surface soils within the community of Flin Flon. Information about concentrations of these and other elements in surface soils in Flin Flon is very limited. A survey conducted by Manitoba Environment and Workplace Safety and Health in 1982 investigated Pb concentrations in soil and sod and found that levels were elevated above background concentrations at a number of locations in the community (Jones 1983). Several of these concentrations exceeded present guidelines for Pb in soil. This study, however, focused solely on Pb concentrations and was limited to a relatively small number of sites. Several garden related studies have been conducted in Flin Flon over the past two decades (Pip 1991, HBM&S 1994, Jones and Henderson 2006). Although results varied between these studies, they did show that As, Cd, Cu, Pb, Hg, Se, and Zn were usually elevated in Flin Flon garden soils compared to gardens in Cranberry Portage and The Pas. In some instances, the concentrations of these elements in Flin Flon garden soils exceeded established soil quality guidelines. Based on this information Manitoba Conservation

proceeded to conduct a comprehensive survey of the element content of surface soils in Flin Flon (hereafter also includes the satellite community of Channing unless stated otherwise).

The objectives of the survey were:

- to determine the concentrations of metals and other elements in surface soil in the community,
- to describe and illustrate the distribution of metals and other elements in the surface soils and identify areas within the community that may have high concentrations,
- to provide a preliminary assessment of the results by comparing the concentration data to existing CCME soil quality guidelines (CCME 1999).

Manitoba Health, HBM&S, the City of Flin Flon, the Flin Flon School Division, and the regional office of Manitoba Conservation were given an opportunity to comment on the survey objectives and methodology before it began. Since Flin Flon is located adjacent to the boundary with Saskatchewan, the Public Health Unit of the Mamawetan Churchill River Health Region (MCRHR), the Chief Medical Health Officer of Saskatchewan Health, and representatives from Saskatchewan Environment were informed of the study prior to sampling. These consultations lead to expansion of the sampling to include the neighbouring community of Creighton, SK

A detailed assessment of the data in terms of the risk to human health was beyond the scope of the survey. The data will help to identify areas within the community where there are elevated concentrations of metals and other elements, and will assist any future assessment that may be conducted.

Methodology

Site Selection and Sampling Protocol

Site selection focused primarily on locations that were readily accessible to the public. Detailed aerial photography, topographic maps, and the author's knowledge of the community were used to help select sites. An attempt was made to select an adequate number of sites to provide representative coverage of the community and facilitate data analysis and mapping. The

MCRHR, Saskatchewan Health, and Saskatchewan Environment selected the sites in Creighton using similar criteria. A total of 93 sites in Flin Flon and 13 sites in Creighton were selected for the survey (Figures 1 and 2). The majority of the sites were located less that 3 km from the smelter complex and many, particularly those in the downtown and core residential areas of Flin Flon, were within 250 m of another site. Sample sites included parks and playgrounds, boulevards, school yards, vacant lots, and undeveloped parcels of land (Figure 1, Table 1). A single site at the entrance to Bakers Narrows Provincial Park (17.8 km southeast of the smelter) and another site in a park in Cranberry Portage (38.3 km southeast of the smelter) were selected as low impact and background sites, respectively. Each site was assigned a TQ (Terrestrial Quality) number for tracking purposes (Figure 2). All sites were sampled by Manitoba Conservation staff during the week of August 21 to 24, 2006.

Table 1. Sites sampled in Flin Flon and Creighton, August, 2006.

Site Type	Dominant Vegetation	Flin Flon	Creighton	Total
park/playground	sod grasses, forbs	31	5	36*
boulevard	sod grasses, forbs and/or weedy species	31	3	34
vacant land (undeveloped)	native grasses, trees, shrubs, or in some cases no vegetation	12	1	13
vacant land	native grasses, sod grasses, forbs, shrubs	9	1	10
school yard	sod grasses, forbs	5	1	6
golf course	sod grasses	3		3
cemetery	sod grasses, forbs	2		2
residence	sod grasses		2	2

*does not include the Bakers Narrows Provincial Park site and the Cranberry Portage site

park/playground - includes public recreation areas such as sports fields and tot lots, the latter often having a sand box play area and a play structure
boulevard - vegetated areas adjacent to streets
vacant land (undeveloped) - parcels of land within the community that have apparently never been developed and are characterized by rocky outcrops, shallow soil, and native vegetation.
vacant land - empty lots on which some type of development, such as a building or park/playground, existed in the past
school yard - play area similar to a playground, but associated with a school

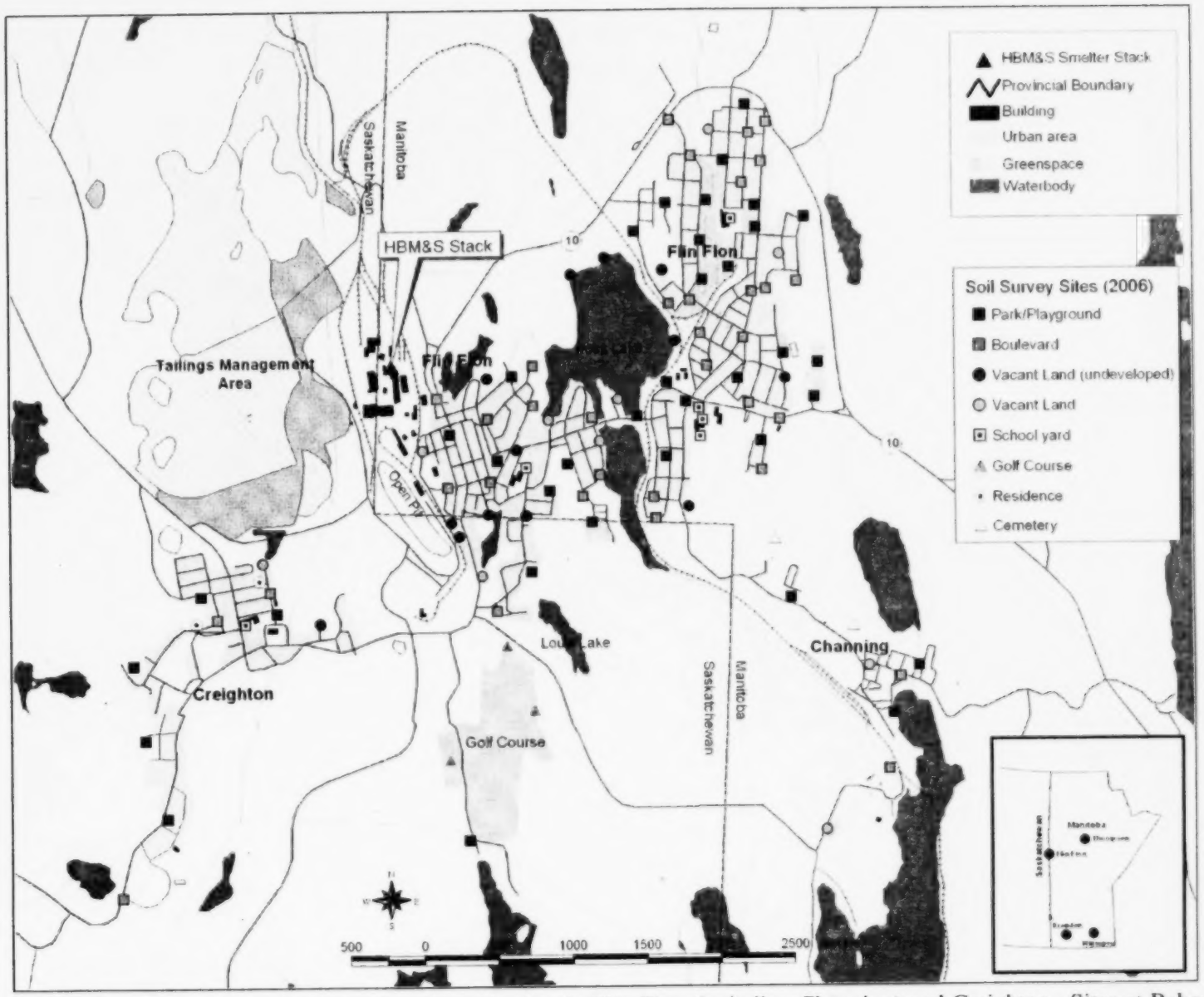


Figure 1. Map of survey area showing location of sample sites in Flin Flon (including Channing) and Creighton. Sites at Bakers Narrows Provincial Park and Cranberry Portage are not shown.

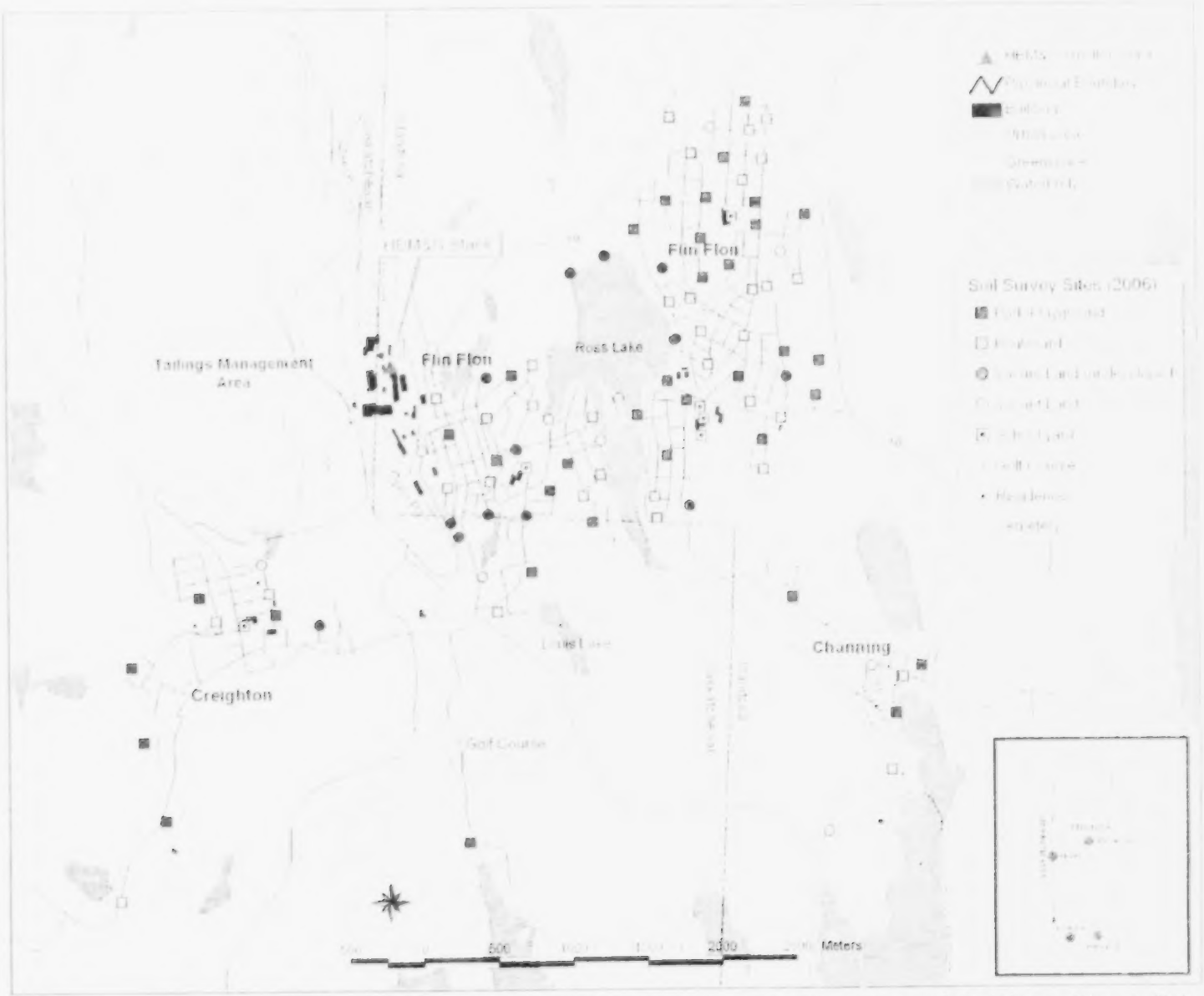


Figure 1. Map of survey area showing location of sample sites in Flin Flon (including Channing) and Creighton. Sites at Bakers Narrows Provincial Park and Cranberry Portage are not shown.

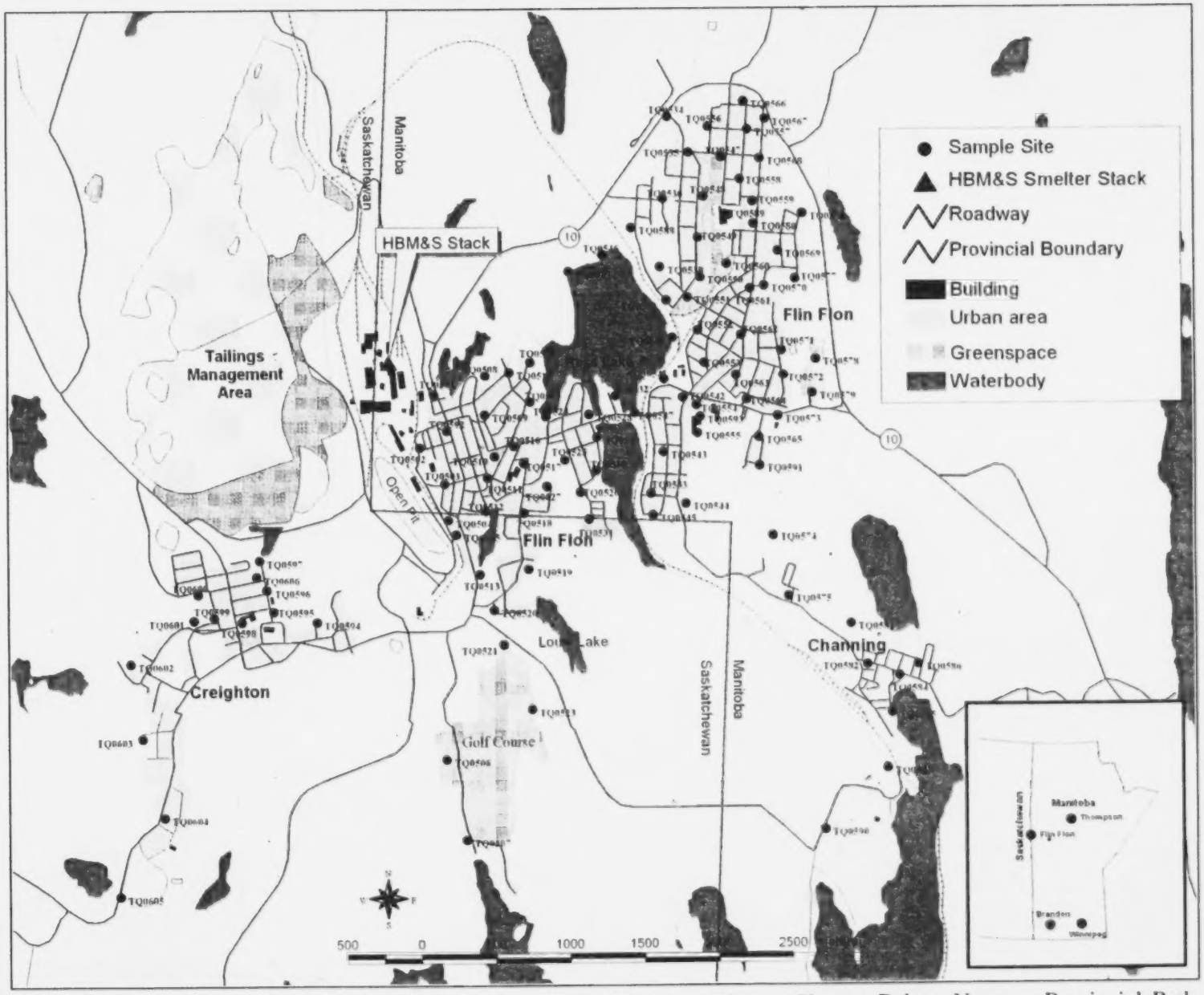


Figure 2. Map of sample sites in Flin Flon and Creighton with TQ site numbers. Sites at Bakers Narrows Provincial Park (TQ0607) and Cranberry Portage (TQ0608) are not shown.

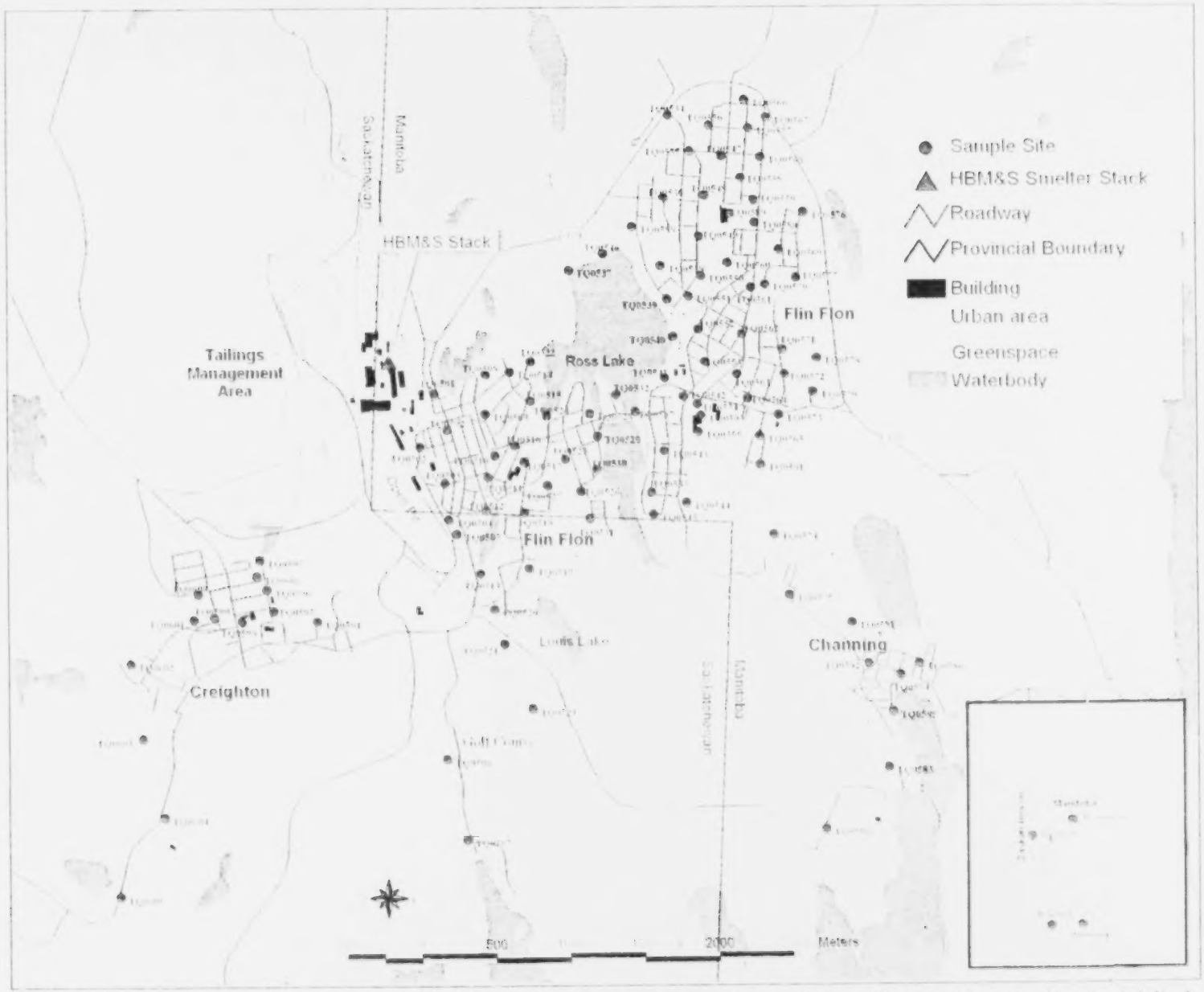
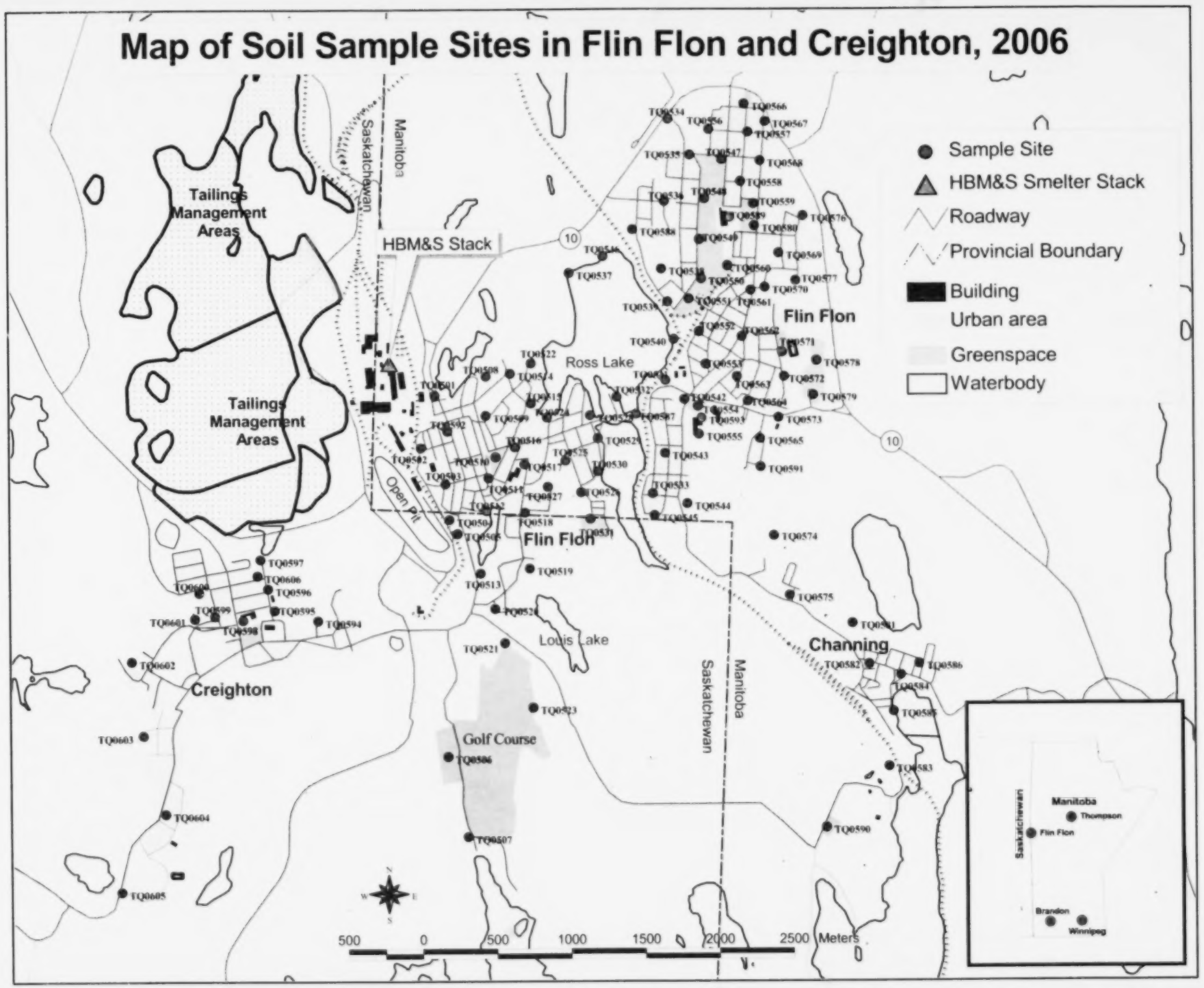


Figure 2. Map of sample sites in Flin Flon and Creighton with TQ site numbers. Sites at Bakers Narrows Provincial Park (TQ0607) and Cranberry Portage (TQ0608) are not shown.

Map of Soil Sample Sites in Flin Flon and Creighton, 2006



The sampling and laboratory analysis methods followed the protocols used in a similar survey conducted in Thompson in 2001 (Jones and Phillips 2003). Sampling points were located away from potential sources of contamination such as roads, parking lots, fences, play structures, and buildings. The top 2.5 cm of the soil profile was extracted using a small diameter (1.5 cm) soil coring tool (Figure 3). Each sample consisted of a composite of 20 cores to ensure that an adequate amount of material was available for analysis. The cores were collected at intervals of approximately 5 cm along a metre stick. The metre stick was placed at three random locations on the ground at each sample site to yield three replicate samples per site. The cores for each sample were placed directly into pre-labeled plastic bags, weighed, and then stored in coolers for transport to Winnipeg. Each site was photographed, geo-referenced with a GPS meter (Garmin 12XL), and the dominant vegetation cover was documented.

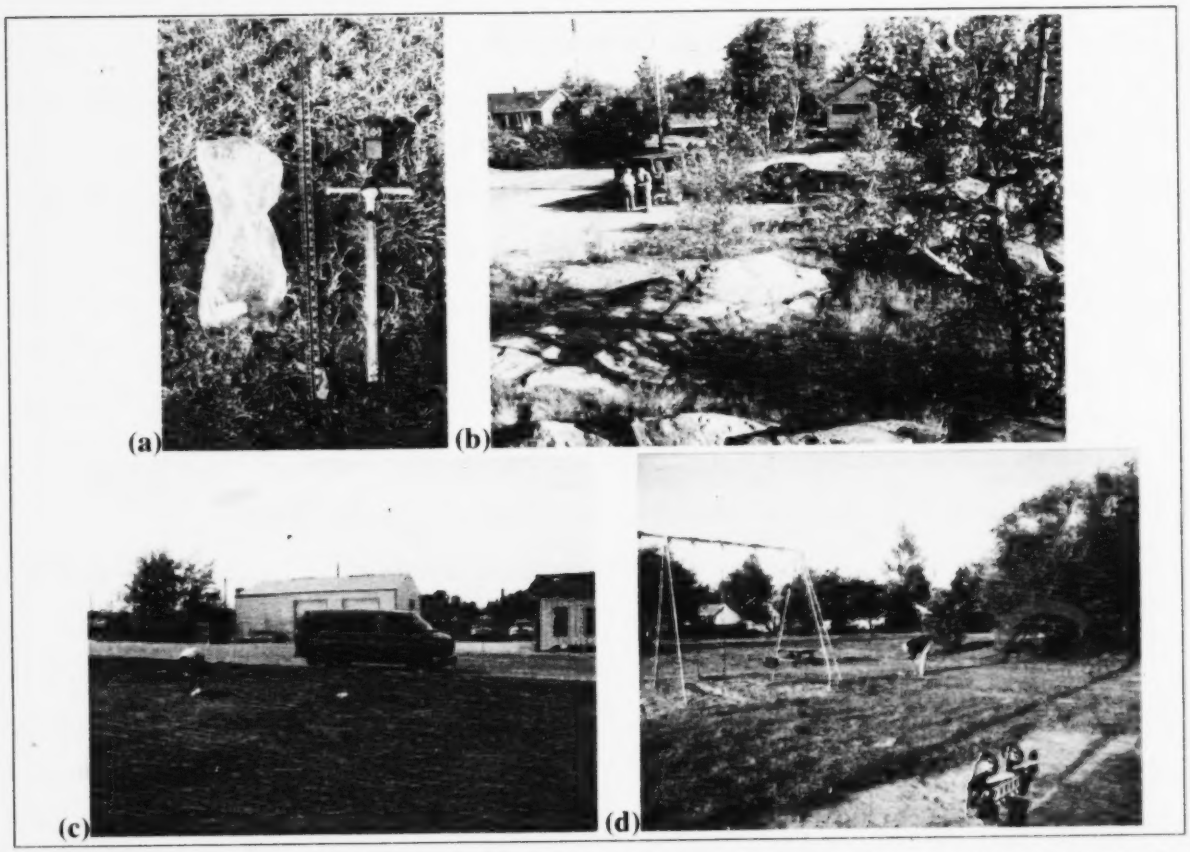


Figure 3. Photographs of soil sampling: (a) sampling apparatus; (b) undeveloped vacant land site (in foreground); (c) boulevard site; (d) park/playground site.

Laboratory Analysis

Samples were dried at 35°C for at least 36 hours and then weighed. The moisture content of each sample was calculated from the wet and dry weights, while the volume of soil collected and the dry weight data were used to calculate bulk density. Dried samples were disaggregated by hand and large pebbles, roots, and other debris were removed. The sample was then homogenized and ground with mortar and pestle to pass through a 2 mm (#10 mesh) sieve. Any material not passing through the sieve was discarded. Analysis for most elements involved strong-acid (HCl and HNO_3) digestion of a sub-sample followed by inductively coupled argon plasma spectroscopy (ICAP). Analyses for As, Cd, Se, Ag, molybdenum (Mo), and thallium (Tl) were performed using inductively coupled plasma mass spectrophotometry (ICP/MS) on a strong-acid digested sub-sample, while analysis for Hg was conducted on a digested sub-sample using cold vapour atomic fluorescence (CVAF). Sulphur (S) was determined using a combustion technique with a Leco Induction Furnace. Analysis of each element was for the total amount and did not differentiate between organic, inorganic, elemental or other fractions in the soil. Soil pH was determined by placing a pH meter probe in a 2:1 water:soil saturated paste extract. Laboratory analyses were done by Cantest Laboratories Ltd., Burnaby, BC. Most concentrations were reported in µg/g dried soil, which is equivalent to parts per million (ppm). Table 2 provides a complete list of elements and other variables analyzed.

Table 2. List of elements and other variables analyzed.

Element/Analyte	Symbol	Detection Limit	Unit	Element/Analyte	Symbol	Detection Limit	Unit
Moisture Content		0.1	%	Manganese	Mn	1	µg/g
Bulk Density		0.01	g/cm^3	Mercury	Hg	0.01	µg/g
pH		0.1	pH units	Molybdenum	Mo	0.1	µg/g
Aluminum	Al	10	µg/g	Nickel	Ni	2	µg/g
Antimony	Sb	0.1	µg/g	Phosphorus (as phosphate)	PO_4	20	µg/g
Arsenic	As	0.1	µg/g	Potassium	K	10	µg/g
Barium	Ba	1	µg/g	Selenium	Se	0.2	µg/g
Beryllium	Be	1	µg/g	Silver	Ag	0.1	µg/g
Boron	B	1	µg/g	Sodium	Na	5	µg/g
Cadmium	Cd	0.2	µg/g	Strontium	Sr	1	µg/g
Calcium	Ca	1	µg/g	Sulphur	S	0.01	%
Chromium	Cr	2	µg/g	Thallium	Tl	0.1	µg/g
Cobalt	Co	1	µg/g	Tin	Sn	5	µg/g
Copper	Cu	1	µg/g	Titanium	Ti	1	µg/g
Iron	Fe	2	µg/g	Vanadium	V	1	µg/g
Lead	Pb	0.2	µg/g	Zinc	Zn	1	µg/g
Magnesium	Mg	1	µg/g	Zirconium	Zr	1	µg/g

Data Analysis, Mapping, and Soil Quality Assessment

The mean concentration (± standard deviation) of each element at each site was calculated from the three replicate samples. Since the mean concentration data did not follow a normal distribution (Shapiro-Wilk W-test), the non-parametric Spearman rank order method of correlation was used to determine the degree of association between elements. This method produces a correlation coefficient value called Spearman's rho, which ranges between -1 and 1. A negative coefficient from the correlation of two variables indicates that as one variable increases the other variable decreases, while a positive coefficient indicates that as one variable increases the other variable also increases. The closer the coefficient is to -1 or 1 the stronger the negative or positive correlation. A coefficient near or at zero indicates that the variables are not correlated with each other.

ArcView GIS (Vers. 3.3) (ESRI 2002) and *ArcView Spatial Analyst* (Vers. 2.0) (ESRI 2000) were used to create maps to show the potential spatial distribution of each element in soil across the study area. This was done by first importing the mean concentration data for each element into *ArcView GIS* and then interpolating the data using the *ArcView Spatial Analyst* extension (specifically the inverse distance weighted (IDW) function with the nearest neighbour default option). This generated a surface grid map layer for each element representing the projected concentration of each element across the entire study area. The surface grid layers were then overlain on a 1:50,000 scale topographic base map in *ArcView GIS* and cropped (using a 300 m buffer) to show only the interpolation results for areas of Flin Flon and Creighton.

It must be recognized that the map layers created by this interpolation method are statistical approximations of what concentrations might be between the sample sites. The only soil element concentrations that are known for certain are those obtained specifically from the sample sites. The map layers are based solely on the data collected from the sites and the actual concentrations between sites may differ considerably from the interpolated concentrations. Variation in soil texture, pH, organic matter content, origin and underlying geology, length of exposure to atmospheric emissions and other sources of contamination, vegetation cover, land use practices, and topography will all influence the concentrations of the various elements in the soil. Also, since the IDW interpolation method used a nearest neighbour algorithm, the accuracy of the concentration grid layer produced is lowest along the edges of the study area and in areas with

fewer sites. Conversely, confidence in the results of the interpolation increases in areas where sites are numerous and closer together. With all this in mind, the map layers produced should only be used as a source of general information about the possible distribution of elements in the soil and cannot be used to directly infer concentrations in soils beyond those areas that were actually sampled.

Lastly, the mean concentration data were compared to existing Canadian soil quality guidelines (CCME 1999) to provide an assessment of the surface soils in Flin Flon and Creighton. Canadian soil quality guidelines are scientifically defensible, numerical limits derived to protect both environmental and human health within four main classes of land use: (1) agricultural, (2) residential/parkland, (3) commercial, and (4) industrial (CCME 1999). The guidelines for human health and for environmental health can differ depending on the chemical or element in question and the type of land use involved. The overall recommended CCME guideline for a substance in soil is always the lower of the two for each of the four land use categories (CCME 1999). For example, if the intended land use of an area is agricultural, and the human health guideline for a given chemical or element in soil intended for agricultural use is 15 µg/g, and the guideline for environmental health is 10 µg/g, the recommended CCME guideline for that chemical or element in agricultural soil would be 10 µg/g. It must be stressed that the CCME guidelines are for general guidance only and site-specific conditions should be considered in the application of these values. Recent examples where CCME soil quality guidelines have been used in the preliminary assessment of the potential and extent of soil contamination in an urban setting include soil surveys conducted in Thompson, MB (Jones and Phillips 2003) and Dalhousie, NB (Cantox Environmental Inc. *et al.* 2006). Since this soil survey focused mainly on parks, playgrounds, and other publicly accessible areas in Flin Flon and Creighton, the CCME residential/parkland guidelines derived specifically for the protection of human health were used to assess the soil results.

CCME residential/parkland guidelines for human health protection have not been derived for all of the elements analyzed in this survey. Those elements without a CCME soil quality guideline were evaluated using interim environmental quality criteria for residential/parkland land use (CCME 1991). These CCME environmental quality criteria are essentially precursors to soil quality guidelines and are not entirely scientifically defensible because of a current lack of

information about the element. However, they are considered to be protective of human and environmental health on the basis of experience and professional judgment (CCME 1999).

Results

General Results

Summary statistics for each of the variables measured, along with a complete list of results from each site, can be found in the Appendix section of this report.

The physical and chemical characteristics of surface soils in Flin Flon and Creighton were quite variable. Soil at some sites had very high proportions of organic material while at others the soil was a mixture of varying amounts of organic material and sand, silt, and clay fractions (Figure 4). Soil at a few sites consisted of a thin layer of organic material over dense clay or gravely sand. This variation in texture resulted in a wide range in soil bulk density values; from a mean of 0.28 g/cm^3 at a residential site in Creighton to 1.67 g/cm^3 at a playground site, also in Creighton. Most soils were relatively dry at the time of sampling (i.e. less than 30 % moisture content), the exception being organic soils, which, having a higher water holding capacity, usually had a moisture content in the range of 40 % to 60 %. Mean soil pH across the study area ranged from 4.0 to a high of 7.8, but on average was slightly acidic (mean and median values of pH 6.2).

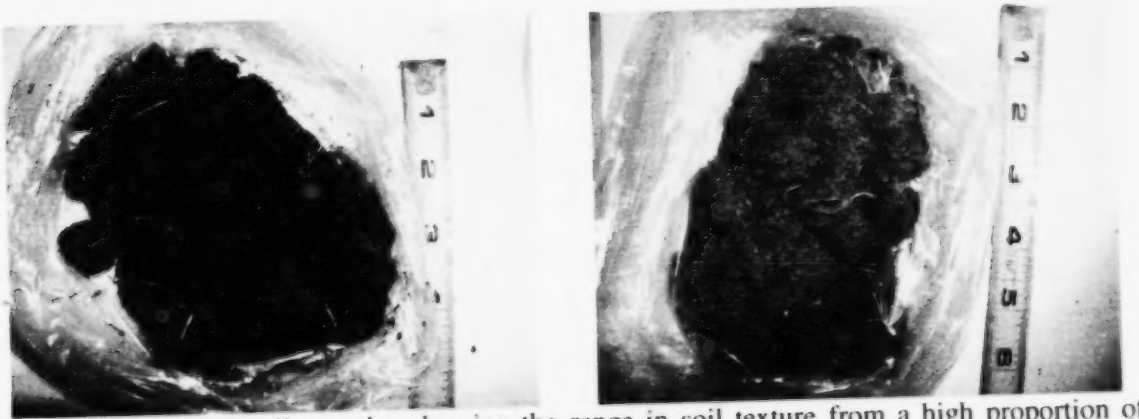


Figure 4. Selected soil samples showing the range in soil texture from a high proportion of organic material (left) to a sample consisting mainly of sand particles (right). Note that the measuring tape is in inches.

Vegetation cover on school yards, parks/playgrounds, vacant lands, and boulevards consisted mainly of non-native grasses and weedy forbs (broadleaf species) such as clover, plantain, and dandelion. Native and introduced trees and shrubs were also present at a few of the park/playground sites. Vegetation at sites located on undeveloped parcels of land consisted mainly of native trees and shrubs along with brown bent-grass (*Agrostis capillaris* L.), a metal tolerant grass species (Winterhalder 2003). In some cases vegetation at these latter sites was sparse and appeared to be under considerable stress.

Concentrations of most of the elements were well above their laboratory detection limits at the sites sampled. Exceptions to this included beryllium (Be), which was above the detection limit (1 µg/g) at only four sites, and tin (Sn), which was above the detection limit (5 µg/g) at five sites. Concentrations of zirconium (Zr) were below the detection limit (1 µg/g) at almost 60 % of sites, and only slightly above the detection limit at most of the remaining sites.

Spearman correlation analysis indicated that As, Cd, Cu, Pb, Hg, Se, Ag, Zn, and antimony (Sb), and to a somewhat lesser degree Mo, S, and Tl, were strongly positively inter-correlated (Table 3). This means, for example, that high concentrations of Cd in the soil were usually accompanied by high concentrations of the other elements listed. Arsenic, Cd, Cu, Pb, Hg, S, and Zn are currently monitored constituents of the HBM&S smelter emissions (MAC 2006). It is likely that Se and Ag are also constituents in the atmospheric emissions since they are by-products of metal production at the complex (Henderson *et al.* 1998). It is also possible that trace amounts of Sb, Mo, and Tl occur in the atmospheric emissions because these elements are often found in association with sulphide deposits and metals such as Cu, Pb, and Zn (CCME 1999). Mean concentrations of Sb, As, Cd, Cu, Pb, Hg, Mo, Se, Ag, S, Tl, and Zn were, with few exceptions, higher in samples collected from Flin Flon and Creighton than in samples collected at the background site in Cranberry Portage. The positive inter-correlation between these elements, their elevated concentrations in soil close to the smelter, and the fact that they are known or suspected constituents of atmospheric emissions implies that the smelter complex is an important source of these elements in soils in Flin Flon and Creighton. It must be emphasized, however, that these elements have accumulated over time and the present concentrations represent the cumulative impact of smelter stack emissions and airborne particulates (dust) from the nearby tailings ponds. They may not represent what is being deposited currently or even what was deposited in the recent past.

Table 3. Spearman correlation analysis results. Correlation coefficient values greater than 0.60 are in bold.

	Sb	As	Cd	Cu	Pb	Hg	Mo	Se	Ag	S	Tl	Zn	Al	B	Ba	Ca	Cr	Co	Fe	Mg	Mn	Ni	P	K	Na	Sr	Ti	V
Sb	1.00																											
As	**0.87**	1.00																										
Cd	**0.84**	**0.74**	1.00																									
Cu	**0.85**	**0.80**	**0.90**	1.00																								
Pb	**0.93**	**0.87**	**0.88**	**0.90**	1.00																							
Hg	**0.78**	**0.75**	**0.78**	**0.89**	**0.85**	1.00																						
Mo	**0.63**	**0.68**	**0.69**	**0.81**	**0.70**	**0.69**	1.00																					
Se	**0.88**	**0.87**	**0.86**	**0.94**	**0.92**	**0.94**	**0.76**	1.00																				
Ag	**0.93**	**0.92**	**0.86**	**0.93**	**0.94**	**0.85**	**0.76**	**0.95**	1.00																			
S	0.57	**0.68**	**0.64**	**0.71**	**0.61**	0.59	**0.67**	**0.71**	**0.70**	1.00																		
Tl	**0.75**	**0.72**	**0.66**	**0.65**	**0.75**	**0.60**	0.50	**0.67**	**0.73**	0.42	1.00																	
Zn	**0.84**	**0.74**	**0.89**	**0.87**	**0.89**	**0.81**	0.59	**0.84**	**0.85**	0.50	**0.70**	1.00																
Al	0.18	0.12	0.21	0.15	0.17	0.08	0.02	0.10	0.13	0.05	0.48	0.32	1.00															
B	0.20	0.07	0.39	0.22	0.19	0.09	0.12	0.15	0.15	0.14	0.30	0.35	**0.65**	1.00														
Ba	0.25	0.13	0.32	0.27	0.30	0.22	0.19	0.21	0.21	0.09	0.47	0.37	**0.79**	**0.64**	1.00													
Ca	0.18	0.12	0.30	0.20	0.16	0.07	0.18	0.16	0.17	0.34	0.17	0.18	0.38	**0.68**	0.47	1.00												
Cr	-0.06	-0.02	0.00	0.02	0.02	0.04	0.23	-0.02	-0.02	-0.10	0.13	0.10	0.44	0.29	0.34	0.05	1.00											
Co	0.52	0.55	0.53	0.54	0.54	0.46	0.49	0.51	0.54	0.46	**0.68**	0.58	**0.67**	0.42	**0.60**	0.31	0.39	1.00										
Fe	0.52	0.56	0.45	0.48	0.54	0.44	0.40	0.50	0.52	0.39	**0.73**	0.53	**0.75**	0.42	**0.61**	0.27	0.42	**0.90**	1.00									
Mg	0.08	0.11	0.08	0.05	0.09	0.00	0.03	0.04	0.06	0.11	0.35	0.17	**0.84**	**0.61**	**0.65**	0.59	0.45	**0.64**	**0.69**	1.00								
Mn	0.31	0.28	0.50	0.36	0.36	0.25	0.27	0.29	0.31	0.29	0.47	0.43	**0.64**	**0.68**	**0.67**	0.55	0.21	**0.68**	0.59	0.59	1.00							
Ni	-0.05	-0.03	0.03	0.08	0.03	0.08	0.28	0.01	-0.02	-0.05	0.14	0.15	0.49	0.37	0.46	0.20	**0.93**	0.48	0.45	0.54	0.32	1.00						
P	0.40	0.29	0.54	0.36	0.36	0.18	0.26	0.33	0.36	0.44	0.35	0.35	0.39	0.59	0.38	0.48	-0.07	0.41	0.41	0.27	0.59	-0.04	1.00					
K	-0.10	-0.14	0.03	-0.05	-0.05	-0.07	-0.07	-0.11	-0.12	-0.04	0.20	0.12	**0.79**	0.55	**0.65**	0.34	0.53	0.50	0.49	**0.75**	0.49	0.57	0.25	1.00				
Na	0.14	0.12	0.18	0.15	0.17	0.07	0.09	0.09	0.11	0.04	0.35	0.27	**0.71**	**0.70**	0.56	0.46	0.44	0.54	**0.62**	**0.76**	0.57	0.51	0.39	**0.61**	1.00			
Sr	0.26	0.14	0.47	0.35	0.28	0.21	0.24	0.26	0.26	0.29	0.27	0.39	0.43	**0.79**	0.59	**0.80**	0.11	0.32	0.27	0.43	0.57	0.26	0.56	0.37	0.49	1.00		
Ti	-0.04	-0.03	-0.03	-0.03	0.00	-0.02	-0.06	-0.08	-0.05	-0.14	0.26	0.14	**0.78**	0.40	0.53	0.06	**0.60**	0.46	0.54	**0.67**	0.31	0.57	0.00	**0.80**	0.55	0.13	1.00	
V	0.13	0.11	0.14	0.12	0.15	0.07	0.04	0.08	0.11	0.04	0.42	0.26	**0.95**	0.57	**0.72**	0.29	0.54	**0.67**	**0.78**	**0.84**	0.58	0.56	0.34	**0.80**	**0.73**	0.33	**0.84**	1.00

Known and suspected constituents of atmospheric emissions

Concentrations of chromium (Cr) and nickel (Ni) were highly positively correlated with each other, were uncorrelated with Sb, As, Cd, Cu, Pb, Hg, Mo, Se, Ag, S, Tl, and Zn, and only weakly correlated with the remaining elements. This suggests that Ni and Cr share a common source, but it is likely not atmospheric emissions from the smelter. Concentrations of the remaining elements tended to be inter-correlated with each other to varying degrees and generally uncorrelated with Sb, As, Cd, Cu, Pb, Hg, Mo, Se, Ag, S, Tl, and Zn. Exceptions include Fe and Co, which were very highly correlated with each other and moderately correlated with most other elements analyzed. Beryllium, Sn, and Zr were not included in the Spearman correlation analysis because concentrations were below detection at the majority of sample sites.

Soil Quality Assessment

The previous section identified Sb, As, Cd, Cu, Pb, Hg, Mo, Se, Ag, S, Tl, and Zn, as known and potential constituents in the atmospheric emissions from the smelter complex. As such, the soil quality assessment will focus on these elements. CCME residential/parkland guidelines for the protection of human health have been derived for As, Cd, Cu, Pb, Hg, Se, and Tl (CCME 1999). The residential/parkland guideline for Zn is for environmental health protection and is based on potential impacts on soil microbes, invertebrates, and vegetation (CCME 1999). It does not reflect a human health concern. CCME guidelines have not been derived for Sb, Mo, Ag, and S, however, interim environmental quality criteria are available and were used in their assessment.

Arsenic (As)

Arsenic concentrations in Flin Flon and Creighton ranged from 2.3 µg/g to 407 µg/g (Table 4). All but three of the sites (two school yards in Flin Flon and a park in Creighton) had mean concentrations of As higher than the site in Cranberry Portage. The highest As concentrations were found in soil collected in Flin Flon at vacant undeveloped land sites and several boulevard sites. Although a few sites had very high concentrations relative to the rest of the sites sampled, concentrations at more than half of all sites were lower than 20 µg/g. Interpolation and mapping of the data suggests that the highest concentrations of As in surface soils may be found in older more established neighbourhoods of west and central Flin Flon, particularly close to the smelter, and in localized areas south and northeast of the smelter (Figure 5). Similarly, interpolated As concentrations in Creighton were highest in areas in the northeast portion of the community closest to the smelter and tailings impoundment. The map in Figure 5 also indicates that the lowest levels of As are likely to be found in the southern portion of Creighton away from the mine tailings impoundment, in the more recently developed eastern portion of Flin Flon, and in the satellite community of Channing (Figure 5).

The CCME human health protection guideline for As in residential/parkland soil is 12 µg/g (CCME 1999). This guideline is based on the health risk associated with exposure specifically to inorganic forms of As through ingestion of soil particles. Inorganic As, which is readily absorbed by the body and stored in various organs, is considered much more toxic than organic or elemental forms, which are usually rapidly eliminated from the body (CCME 1999). The guideline level of 12 µg/g was exceeded at 61 sites in Flin Flon and nine sites in Creighton, for a total of 70 (66 %) of the 106 sites sampled across the two communities (Table 4). The guideline was exceeded at all of the vacant undeveloped land sites and at nine of the ten vacant lot sites. In addition, concentrations at 23 (67 %) of the boulevard sites and 17 (47 %) of the park/playground sites were above the guideline. Mean concentrations at two of the six school yards sampled – one located in Flin Flon and the other in Creighton – were also above the guideline. Mean concentrations at the sites in Bakers Narrows and Cranberry Portage were well below the guideline.

Table 4. Mean concentrations of As in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. Sites in bold exceeded the residential/parkland human health protection guideline for As (12 µg/g). Creighton sites are enclosed in borders. (n = 3, S.D. = standard deviation).

Site	Site Type	As (ug/g)	S.D.
TQ0557	Boulevard	5.4	1.0
TQ0530	Boulevard	6.3	2.8
TQ0583	Boulevard	7.4	0.4
TQ0573	Boulevard	8.4	0.4
TQ0568	Boulevard	8.4	0.8
TQ0528	Boulevard	9.0	3.3
TQ0591	Boulevard	9.3	3.5
TQ0545	Boulevard	10.5	7.6
TQ0558	Boulevard	10.8	0.6
TQ0561	Boulevard	11.4	3.0
TQ0605	**Boulevard**	**12.3**	**1.8**
TQ0570	**Boulevard**	**13.4**	**1.4**
TQ0564	**Boulevard**	**14.9**	**1.3**
TQ0562	**Boulevard**	**15.1**	**0.7**
TQ0515	**Boulevard**	**15.1**	**0.6**
TQ0577	**Boulevard**	**15.3**	**1.8**
TQ0533	**Boulevard**	**15.9**	**4.6**
TQ0535	**Boulevard**	**16.9**	**0.9**
TQ0553	**Boulevard**	**16.9**	**4.6**
TQ0551	**Boulevard**	**19.5**	**4.0**
TQ0526	**Boulevard**	**22.6**	**3.2**
TQ0522	**Boulevard**	**23.8**	**8.4**
TQ0584	**Boulevard**	**24.4**	**1.2**
TQ0539	**Boulevard**	**25.7**	**9.4**
TQ0552	**Boulevard**	**26.0**	**1.3**
TQ0599	**Boulevard**	**28.2**	**6.6**
TQ0511	**Boulevard**	**29.2**	**10.0**
TQ0534	**Boulevard**	**33.7**	**9.6**
TQ0520	**Boulevard**	**45.0**	**8.7**
TQ0567	**Boulevard**	**46.5**	**19.1**
TQ0503	**Boulevard**	**83.9**	**22.5**
TQ0596	**Boulevard**	**111.7**	**15.0**
TQ0509	**Boulevard**	**112.5**	**42.7**
TQ0501	**Boulevard**	**202.3**	**36.0**
TQ0581	Cemetery	7.6	2.3
TQ0574	Cemetery	10.1	1.9
TQ0601	**Residence**	**49.4**	**14.4**
TQ0606	**Residence**	**87.3**	**49.2**
TQ0604	Park/Playground	2.3	0.3
TQ0536	Park/Playground	3.7	0.8
TQ0603	Park/Playground	3.9	0.6
TQ0541	Park/Playground	4.3	0.4
TQ0585	Park/Playground	5.2	0.5
TQ0602	Park/Playground	5.4	1.3
TQ0565	Park/Playground	7.4	3.8
TQ0542	Park/Playground	7.7	4.4
TQ0600	Park/Playground	8.5	6.5
TQ0579	Park/Playground	8.7	0.6
TQ0571	Park/Playground	9.3	1.6
TQ0576	Park/Playground	9.5	2.1
TQ0548	Park/Playground	9.5	1.9
TQ0563	Park/Playground	9.7	4.5
TQ0580	Park/Playground	9.8	12.0
TQ0586	Park/Playground	10.9	8.6
TQ0575	Park/Playground	11.1	5.1
TQ0543	Park/Playground	11.4	2.8
TQ0588	Park/Playground	11.8	3.4
TQ0559	**Park/Playground**	**12.6**	**3.6**
TQ0566	**Park/Playground**	**13.2**	**5.4**
TQ0578	**Park/Playground**	**13.4**	**0.9**
TQ0519	**Park/Playground**	**13.5**	**3.8**
TQ0550	**Park/Playground**	**14.6**	**8.0**
TQ0510	**Park/Playground**	**15.8**	**10.8**
TQ0560	**Park/Playground**	**17.4**	**0.8**
TQ0527	**Park/Playground**	**18.1**	**6.7**
TQ0547	**Park/Playground**	**19.1**	**15.5**
TQ0587	**Park/Playground**	**22.9**	**9.6**
TQ0531	**Park/Playground**	**26.8**	**11.2**
TQ0514	**Park/Playground**	**26.9**	**6.3**
TQ0507	**Park/Playground**	**28.4**	**5.0**
TQ0549	**Park/Playground**	**32.4**	**20.3**
TQ0525	**Park/Playground**	**33.9**	**10.6**
TQ0592	**Park/Playground**	**42.7**	**10.5**
TQ0595	**Park/Playground**	**63.3**	**9.3**
TQ0521	**Golf Course**	**33.4**	**10.4**
TQ0523	**Golf Course**	**77.1**	**37.1**
TQ0506	**Golf Course**	**160.3**	**15.5**
TQ0524	Vacant Land	8.4	0.7
TQ0569	**Vacant Land**	**13.1**	**1.1**
TQ0532	**Vacant Land**	**14.6**	**2.9**
TQ0529	**Vacant Land**	**14.9**	**2.0**
TQ0590	**Vacant Land**	**21.5**	**13.3**
TQ0556	**Vacant Land**	**32.9**	**3.5**
TQ0582	**Vacant Land**	**36.0**	**14.5**
TQ0502	**Vacant Land**	**47.1**	**5.2**
TQ0597	**Vacant Land**	**57.4**	**35.3**
TQ0513	**Vacant Land**	**78.7**	**8.0**
TQ0572	**Vacant Land (undeveloped)**	**17.7**	**5.3**
TQ0540	**Vacant Land (undeveloped)**	**24.5**	**4.2**
TQ0516	**Vacant Land (undeveloped)**	**44.4**	**27.5**
TQ0512	**Vacant Land (undeveloped)**	**47.7**	**11.6**
TQ0546	**Vacant Land (undeveloped)**	**49.7**	**20.7**
TQ0504	**Vacant Land (undeveloped)**	**80.3**	**32.8**
TQ0538	**Vacant Land (undeveloped)**	**100.0**	**4.5**
TQ0537	**Vacant Land (undeveloped)**	**100.9**	**22.2**
TQ0544	**Vacant Land (undeveloped)**	**108.7**	**36.9**
TQ0594	**Vacant Land (undeveloped)**	**115.7**	**36.7**
TQ0518	**Vacant Land (undeveloped)**	**123.3**	**6.7**
TQ0508	**Vacant Land (undeveloped)**	**258.3**	**56.1**
TQ0505	**Vacant Land (undeveloped)**	**407.0**	**52.7**
TQ0593	School yard	2.5	0.1
TQ0555	School yard	2.5	0.8
TQ0589	School yard	6.1	2.6
TQ0517	School yard	9.7	7.9
TQ0554	**School yard**	**20.5**	**3.5**
TQ0598	**School yard**	**21.9**	**4.5**
TQ0607	Park/Playground (Bakers Narrows)	6.1	0.5
TQ0608	Park/Playground (Cranberry Portage)	2.5	0.5

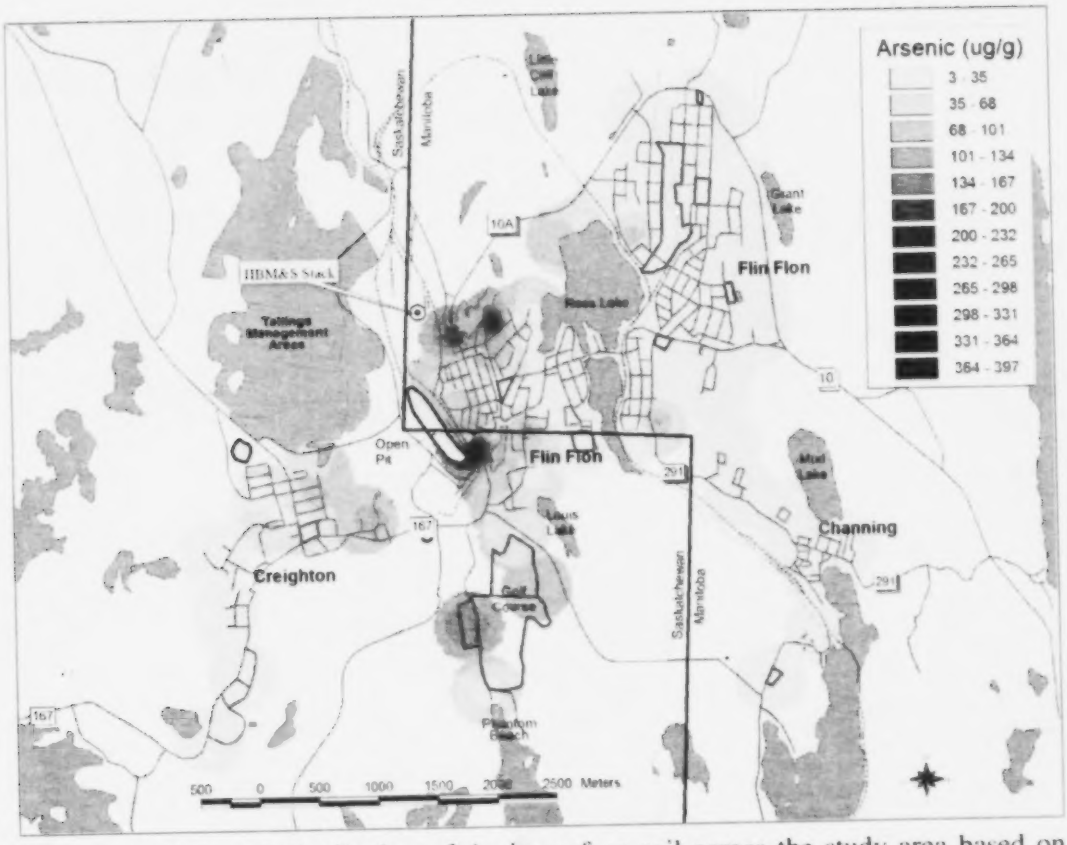


Figure 5. Projected distribution of As in surface soil across the study area based on IDW interpolation of the mean As concentrations at 106 sample sites.

The map from Figure 5 was modified somewhat in Figure 6 to only show the interpolated coverage results with concentrations greater than the As guideline of 12 µg/g. The map indicates that soils throughout much of Flin Flon and a large part of the northern portion of Creighton could potentially exceed the guideline level. However, it must be stressed that the interpolation is only a statistical estimate of what concentrations might be between sample sites and is based solely on the data collected at the sample sites. More sampling would be required to definitively ascertain the concentrations of As beyond the actual sites sampled.

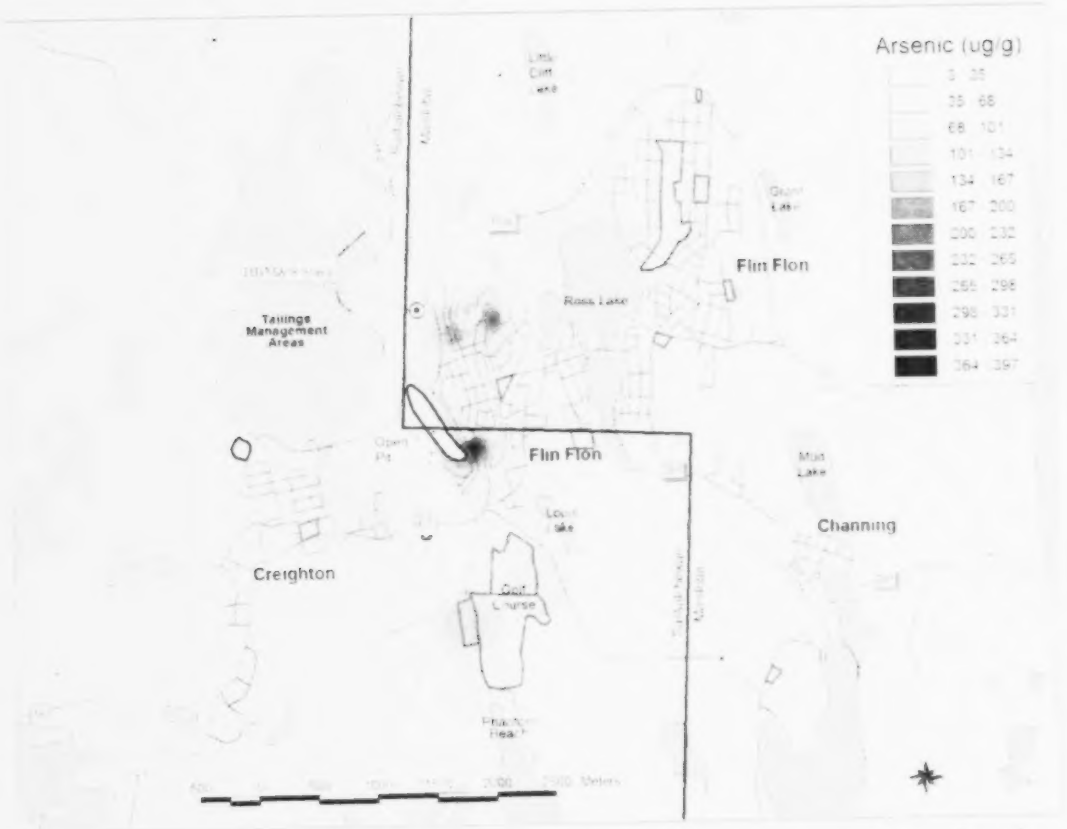


Figure 5. Projected distribution of As in surface soil across the study area based on IDW interpolation of the mean As concentrations at 106 sample sites.

The map from Figure 5 was modified somewhat in Figure 6 to only show the interpolated coverage results with concentrations greater than the As guideline of 12 µg/g. The map indicates that soils throughout much of Flin Flon and a large part of the northern portion of Creighton could potentially exceed the guideline level. However, it must be stressed that the interpolation is only a statistical estimate of what concentrations might be between sample sites and is based solely on the data collected at the sample sites. More sampling would be required to definitively ascertain the concentrations of As beyond the actual sites sampled.

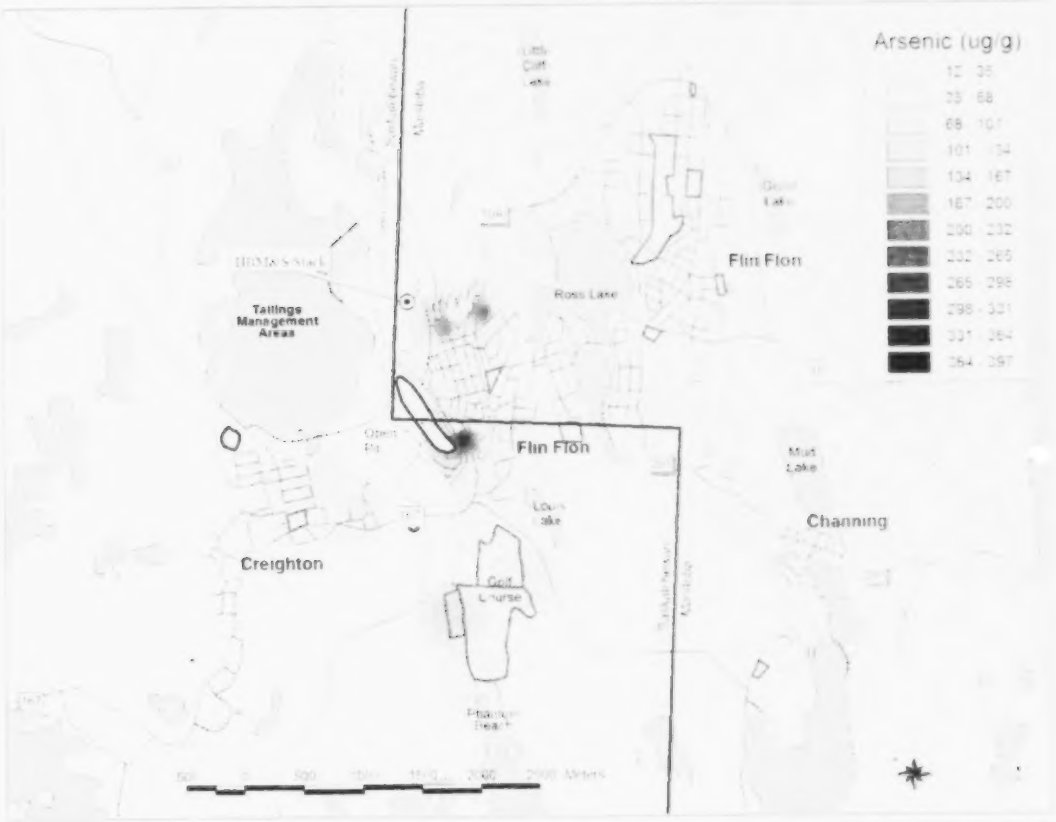


Figure 6. Projected distribution of As concentrations above the guideline level of 12 µg/g in surface soil across the study area based on IDW interpolation of the mean As concentrations at 106 sample sites.

Cadmium (Cd)

Cadmium was detected at all of the sites sampled in Flin Flon and Creighton (Table 5). It was also recorded at the site in Bakers Narrows, but was below detection (<0.2 µg/g) at the site in Cranberry Portage. Concentrations of Cd in Flin Flon ranged from 0.7 µg/g at a school yard site to 70.9 µg/g at one of the undeveloped vacant land sites. The range in concentrations in Creighton was considerably less, with a low of 0.9 µg/g at a park/playground site and a high of 20.8 µg/g at one of the residence sites. Similar to As, the highest concentrations of Cd were found at undeveloped vacant land sites and at boulevard sites. Relatively high values were also measured at a few parks/playgrounds in Flin Flon, as well as at one of the golf course sites. The interpolation results suggests that the distribution of Cd is fairly even across the study area, with

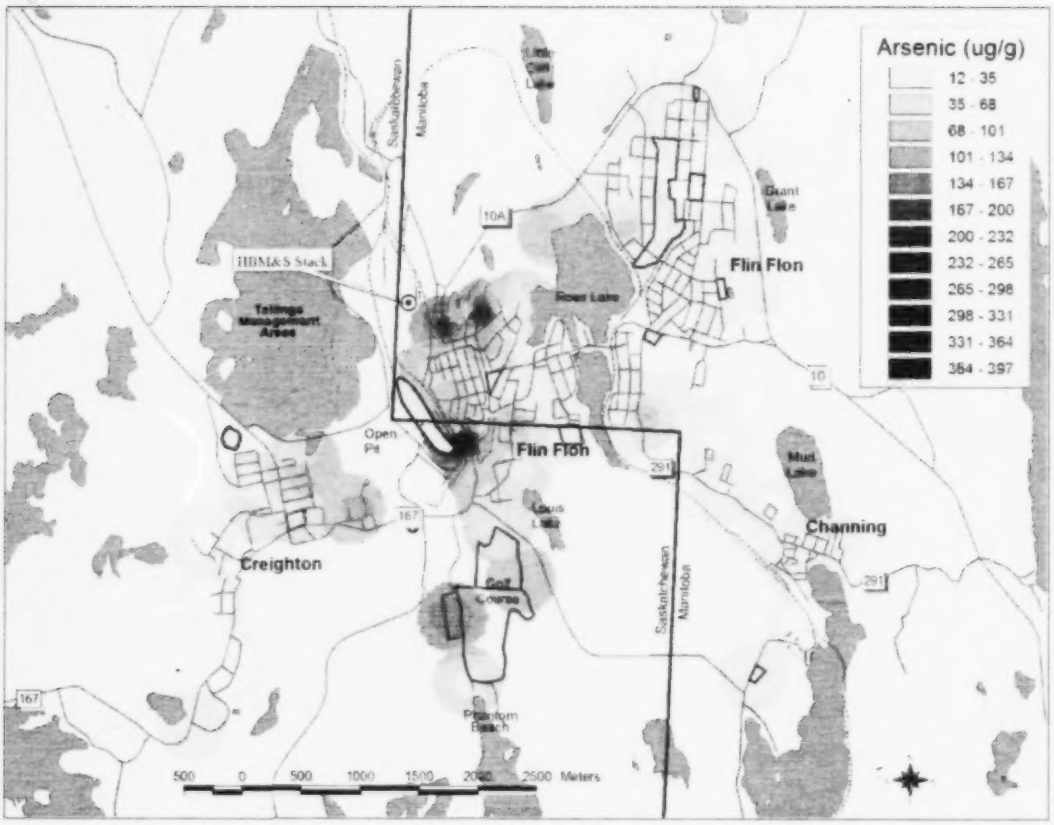


Figure 6. Projected distribution of As concentrations above the guideline level of 12 µg/g in surface soil across the study area based on IDW interpolation of the mean As concentrations at 106 sample sites.

Cadmium (Cd)

Cadmium was detected at all of the sites sampled in Flin Flon and Creighton (Table 5). It was also recorded at the site in Bakers Narrows, but was below detection (<0.2 µg/g) at the site in Cranberry Portage. Concentrations of Cd in Flin Flon ranged from 0.7 µg/g at a school yard site to 70.9 µg/g at one of the undeveloped vacant land sites. The range in concentrations in Creighton was considerably less, with a low of 0.9 µg/g at a park/playground site and a high of 20.8 µg/g at one of the residence sites. Similar to As, the highest concentrations of Cd were found at undeveloped vacant land sites and at boulevard sites. Relatively high values were also measured at a few parks/playgrounds in Flin Flon, as well as at one of the golf course sites. The interpolation results suggests that the distribution of Cd is fairly even across the study area, with

localized areas of high concentration in the more well–established west-central area of Flin Flon and areas northeast and east of the smelter near Ross Lake (Figure 7).

Table 5. Mean concentrations of Cd in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. Sites in bold exceeded the residential/parkland human health protection guideline for Cd (14 µg/g). Creighton sites are enclosed in borders. (n = 3, S.D. = standard deviation).

Site	Site Type	Cd (ug/g)	S.D.
TQ0530	Boulevard	3.4	0.9
TQ0573	Boulevard	3.4	0.2
TQ0557	Boulevard	3.5	0.6
TQ0583	Boulevard	4.1	0.8
TQ0599	Boulevard	4.3	1.5
TQ0528	Boulevard	4.4	1.4
TQ0591	Boulevard	5.7	4.9
TQ0545	Boulevard	5.9	4.7
TQ0558	Boulevard	6.9	1.6
TQ0568	Boulevard	7.3	2.4
TQ0534	Boulevard	9.1	3.2
TQ0564	Boulevard	9.1	2.4
TQ0570	Boulevard	9.4	1.5
TQ0561	Boulevard	9.6	4.0
TQ0520	Boulevard	10.5	5.1
TQ0596	Boulevard	10.9	1.9
TQ0522	Boulevard	11.3	4.4
TQ0577	Boulevard	11.6	0.4
TQ0553	Boulevard	11.8	3.7
TQ0511	Boulevard	11.8	4.7
TQ0562	Boulevard	12.0	1.0
TQ0535	Boulevard	12.2	0.8
TQ0515	Boulevard	12.3	1.0
TQ0605	Boulevard	12.3	1.4
TQ0533	Boulevard	12.4	2.4
TQ0551	Boulevard	12.6	1.6
TQ0552	**Boulevard**	**14.2**	**2.8**
TQ0567	**Boulevard**	**14.2**	**4.4**
TQ0584	**Boulevard**	**16.6**	**2.2**
TQ0526	**Boulevard**	**17.6**	**1.8**
TQ0503	**Boulevard**	**22.8**	**4.6**
TQ0509	**Boulevard**	**29.6**	**19.0**
TQ0501	**Boulevard**	**39.3**	**7.7**
TQ0539	**Boulevard**	**49.1**	**35.4**
TQ0581	Cemetery	3.8	1.9
TQ0574	Cemetery	8.8	0.9
TQ0606	Residence	8.0	2.9
TQ0601	**Residence**	**20.8**	**7.7**

Site	Site Type	Cd (ug/g)	S.D.
TQ0604	Park/Playground	0.9	0.1
TQ0541	Park/Playground	1.0	0.1
TQ0536	Park/Playground	1.9	0.2
TQ0603	Park/Playground	2.1	0.6
TQ0602	Park/Playground	2.3	1.0
TQ0600	Park/Playground	2.8	2.9
TQ0580	Park/Playground	2.9	0.6
TQ0542	Park/Playground	3.1	2.4
TQ0527	Park/Playground	4.4	1.2
TQ0519	Park/Playground	4.6	1.0
TQ0585	Park/Playground	4.7	0.3
TQ0548	Park/Playground	5.8	5.8
TQ0565	Park/Playground	5.9	3.0
TQ0575	Park/Playground	6.7	2.0
TQ0571	Park/Playground	7.4	3.6
TQ0578	Park/Playground	7.8	1.7
TQ0550	Park/Playground	8.8	1.9
TQ0510	Park/Playground	8.9	8.0
TQ0588	Park/Playground	10.1	5.0
TQ0560	Park/Playground	10.2	1.6
TQ0587	Park/Playground	10.2	2.8
TQ0576	Park/Playground	10.8	0.2
TQ0531	Park/Playground	10.9	2.3
TQ0595	Park/Playground	11.1	0.7
TQ0566	Park/Playground	11.3	3.3
TQ0507	Park/Playground	12.1	2.5
TQ0586	Park/Playground	12.4	11.8
TQ0579	Park/Playground	12.7	3.0
TQ0543	**Park/Playground**	**14.4**	**4.1**
TQ0563	**Park/Playground**	**15.3**	**8.1**
TQ0592	**Park/Playground**	**15.4**	**2.4**
TQ0525	**Park/Playground**	**16.4**	**9.6**
TQ0559	**Park/Playground**	**17.1**	**0.2**
TQ0547	**Park/Playground**	**17.5**	**12.4**
TQ0549	**Park/Playground**	**21.9**	**6.8**
TQ0514	**Park/Playground**	**24.2**	**9.4**
TQ0506	Golf Course	11.3	1.3
TQ0521	**Golf Course**	**16.4**	**2.2**
TQ0523	**Golf Course**	**40.8**	**18.4**

Site	Site Type	Cd (ug/g)	S.D.
TQ0524	Vacant Land	2.8	0.5
TQ0597	Vacant Land	3.0	2.0
TQ0529	Vacant Land	5.0	0.7
TQ0532	Vacant Land	6.7	1.6
TQ0590	Vacant Land	12.9	9.0
TQ0582	Vacant Land	13.3	6.5
TQ0502	**Vacant Land**	**16.5**	**3.5**
TQ0569	**Vacant Land**	**16.6**	**4.3**
TQ0513	**Vacant Land**	**18.6**	**1.8**
TQ0556	**Vacant Land**	**19.7**	**3.1**
TQ0594	Vacant Land (undeveloped)	8.2	0.2
TQ0572	Vacant Land (undeveloped)	8.4	5.8
TQ0504	Vacant Land (undeveloped)	12.5	1.6
TQ0512	**Vacant Land (undeveloped)**	**14.1**	**3.6**
TQ0516	**Vacant Land (undeveloped)**	**14.3**	**9.5**
TQ0544	**Vacant Land (undeveloped)**	**14.9**	**0.7**
TQ0505	**Vacant Land (undeveloped)**	**16.6**	**3.5**
TQ0518	**Vacant Land (undeveloped)**	**26.3**	**9.3**
TQ0546	**Vacant Land (undeveloped)**	**30.5**	**11.6**
TQ0540	**Vacant Land (undeveloped)**	**33.3**	**18.5**
TQ0508	**Vacant Land (undeveloped)**	**41.7**	**13.4**
TQ0538	**Vacant Land (undeveloped)**	**42.4**	**16.6**
TQ0537	**Vacant Land (undeveloped)**	**70.9**	**13.0**
TQ0593	School yard	0.7	0.1
TQ0555	School yard	1.8	0.3
TQ0517	School yard	3.7	2.3
TQ0589	School yard	4.1	2.2
TQ0598	School yard	8.7	2.4
TQ0554	School yard	12.4	6.3
TQ0607	Park/Playground (Bakers Narrows)	1.4	0.4
TQ0608	Park/Playground (Cranberry Portage)	<0.2	

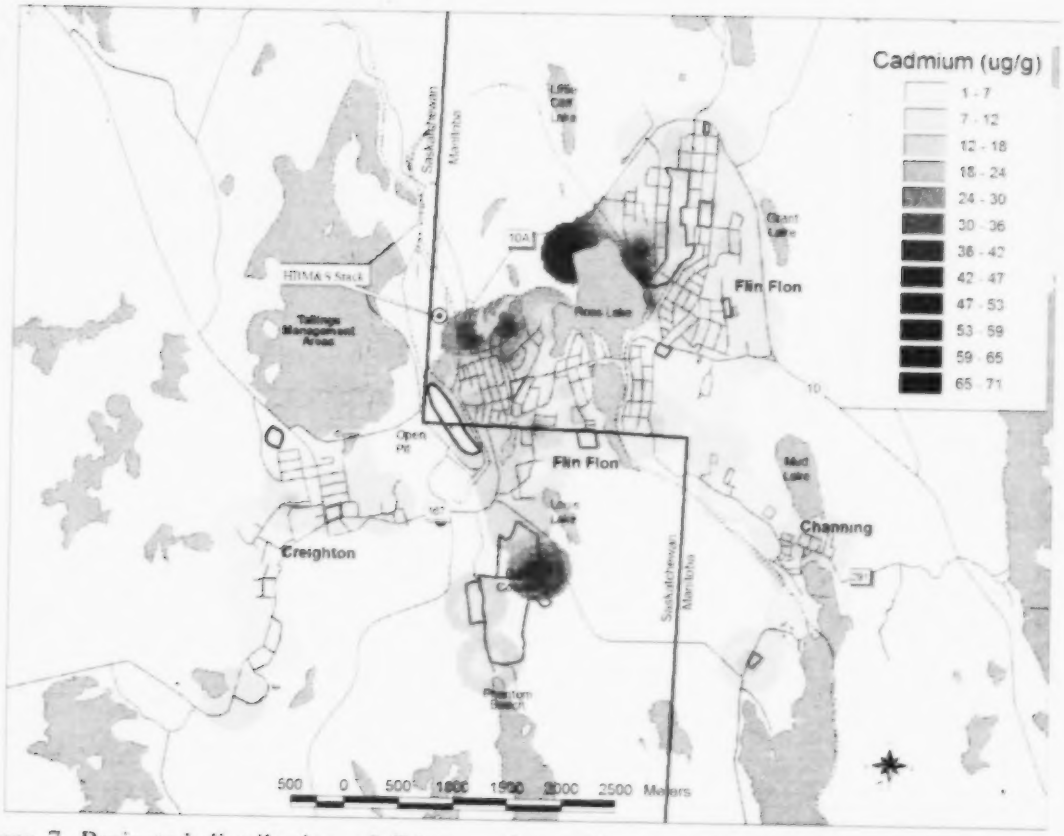


Figure 7. Projected distribution of Cd in surface soil across the study area based on IDW interpolation of the mean Cd concentrations at 106 sample sites.

The CCME residential/parkland human health protection guideline for Cd in soil is 14 µg/g (CCME 1999). This guideline is based on the health risk associated with ingesting soil containing Cd. Thirty-two sites in Flin Flon and a single site in Creighton had concentrations of Cd above the guideline (Table 5). The majority of these sites were located on undisturbed vacant land (10 sites), parks/playgrounds (8 sites), and boulevards (7 sites). None of the school yard sites exceeded the guideline, and levels at only four of the 10 vacant lot sites were above the guideline. In many cases the guideline was exceeded by a relatively small margin and was often within the standard deviation of the mean concentration at the sites.

The interpolation results indicate that Cd concentrations may exceed the guideline level in older areas of Flin Flon immediately south-southeast and east-northeast of the smelter (Figure 8). However, soil concentrations in much of the more recently developed eastern half of Flin Flon and the residential area south of the north basin of Ross Lake are potentially below the guideline

level. Furthermore, based on the data collected, Cd levels in soil in most areas of Channing and Creighton are expected to be below the guideline.

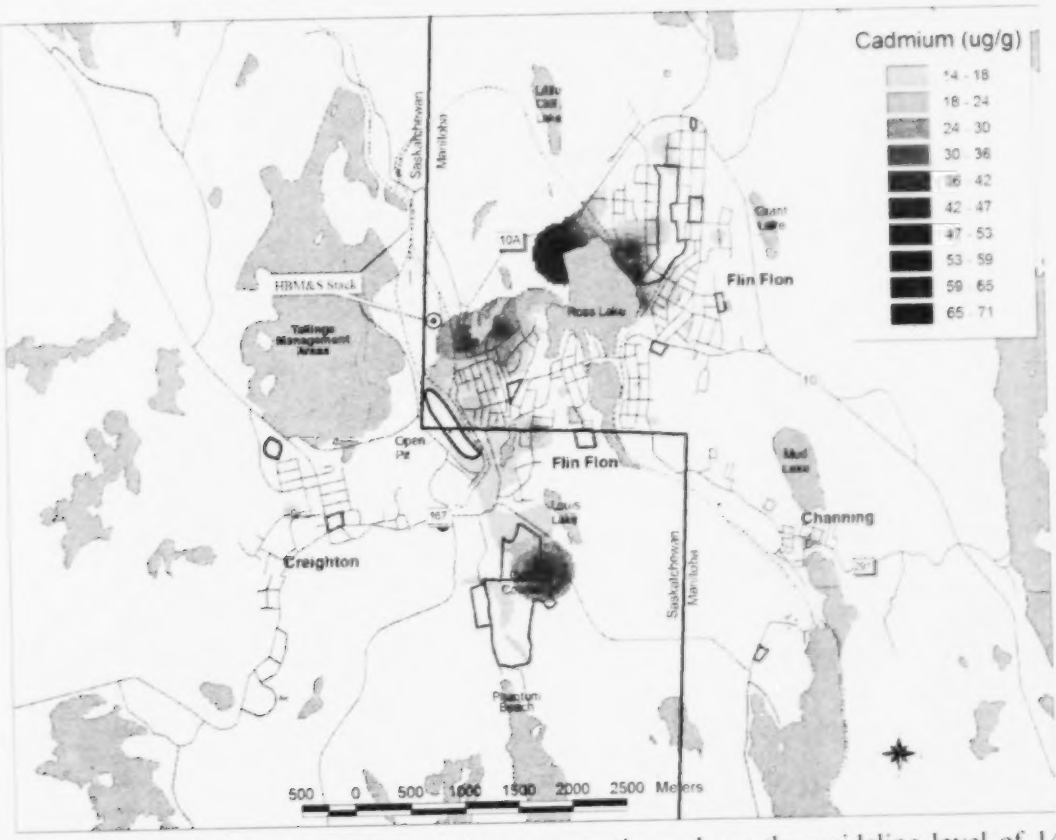


Figure 8. Projected distribution of Cd concentrations above the guideline level of 14 µg/g in surface soil across the study area based on IDW interpolation of the mean Cd concentrations at 106 sample sites.

Copper (Cu)

Copper concentrations in Flin Flon ranged from 54 µg/g at a park/playground site to 5103 µg/g at an undeveloped vacant land site (Table 6). The range in concentrations in Creighton was considerably lower (53 µg/g to 899 µg/g). Mean concentrations at all sites in Flin Flon and Creighton were higher than the site in Cranberry Portage. Sites with the highest concentrations of Cu tended to be vacant undeveloped land and boulevards. The interpolation results indicate that the highest concentrations of Cu within the survey area may be found in the older, western

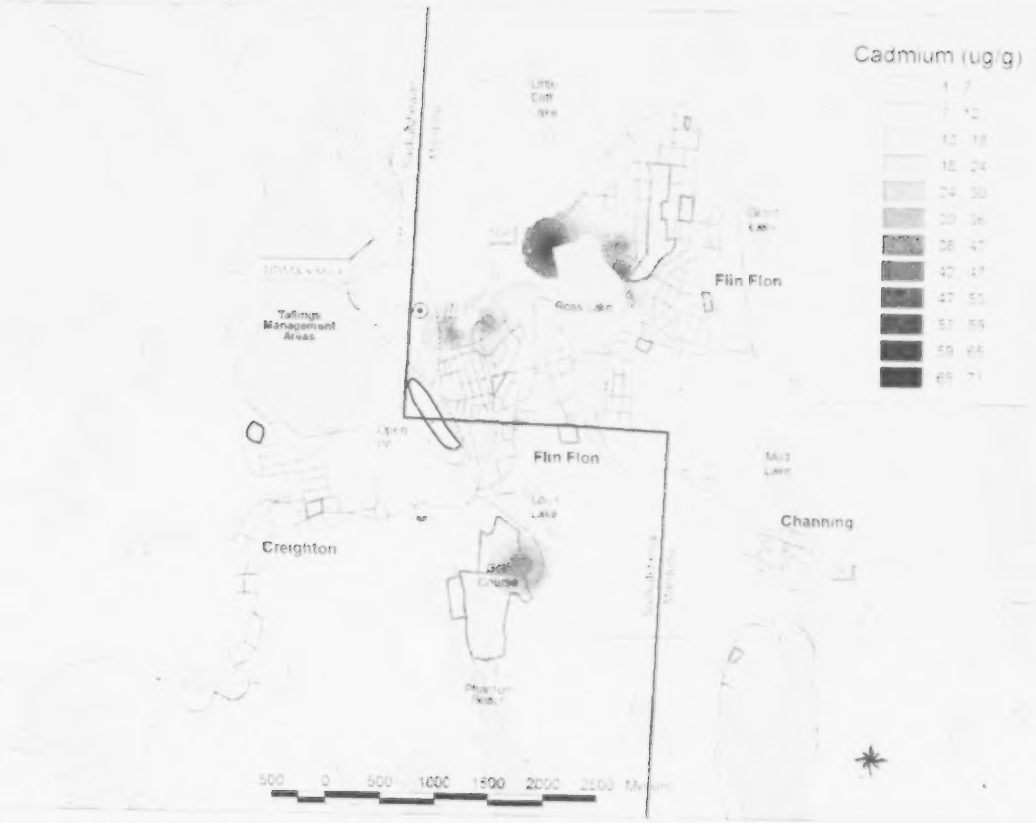


Figure 7. Projected distribution of Cd in surface soil across the study area based on IDW interpolation of the mean Cd concentrations at 106 sample sites.

The CCME residential/parkland human health protection guideline for Cd in soil is 14 µg/g (CCME 1999). This guideline is based on the health risk associated with ingesting soil containing Cd. Thirty-two sites in Flin Flon and a single site in Creighton had concentrations of Cd above the guideline (Table 5). The majority of these sites were located on undisturbed vacant land (10 sites), parks/playgrounds (8 sites), and boulevards (7 sites). None of the school yard sites exceeded the guideline, and levels at only four of the 10 vacant lot sites were above the guideline. In many cases the guideline was exceeded by a relatively small margin and was often within the standard deviation of the mean concentration at the sites.

The interpolation results indicate that Cd concentrations may exceed the guideline level in older areas of Flin Flon immediately south-southeast and east-northeast of the smelter (Figure 8). However, soil concentrations in much of the more recently developed eastern half of Flin Flon and the residential area south of the north basin of Ross Lake are potentially below the guideline

level. Furthermore, based on the data collected, Cd levels in soil in most areas of Channing and Creighton are expected to be below the guideline.

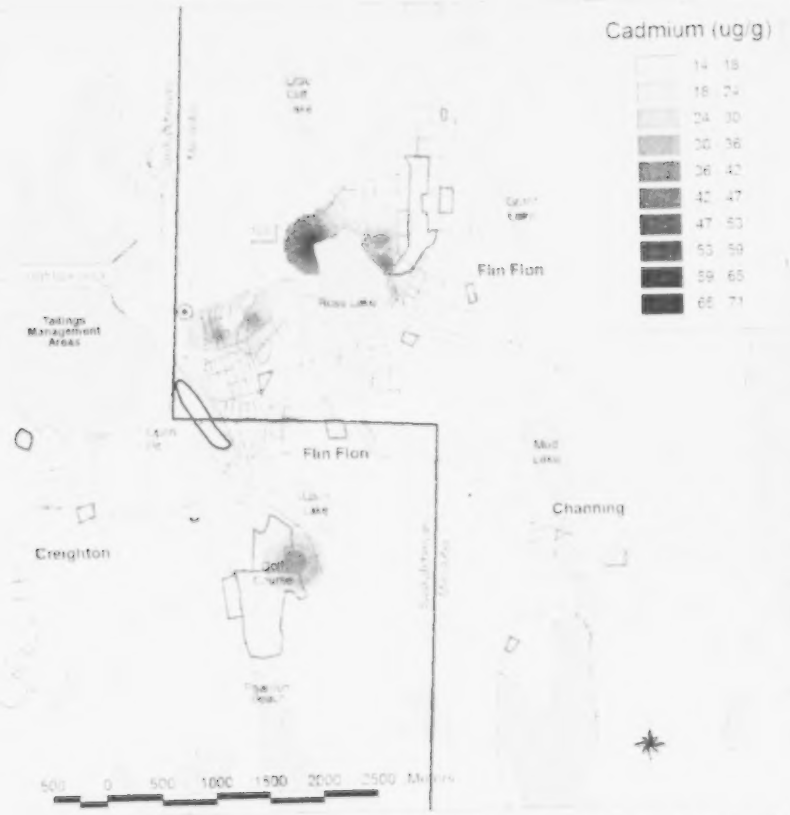


Figure 8. Projected distribution of Cd concentrations above the guideline level of 14 µg/g in surface soil across the study area based on IDW interpolation of the mean Cd concentrations at 106 sample sites.

Copper (Cu)

Copper concentrations in Flin Flon ranged from 54 µg/g at a park/playground site to 5103 µg/g at an undeveloped vacant land site (Table 6). The range in concentrations in Creighton was considerably lower (53 µg/g to 899 µg/g). Mean concentrations at all sites in Flin Flon and Creighton were higher than the site in Cranberry Portage. Sites with the highest concentrations of Cu tended to be vacant undeveloped land and boulevards. The interpolation results indicate that the highest concentrations of Cu within the survey area may be found in the older, western

portion of Flin Flon, while the lowest concentrations likely occur in the eastern portion of the study area and in Creighton (Figure 9).

Table 6. Mean concentrations of Cu in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. Sites in bold exceeded the residential/parkland human health protection guideline for Cu (1100 µg/g). Creighton sites are enclosed in borders. (n = 3, S.D. = standard deviation).

Site	Site Type	Cu (ug/g)	S.D.
TQ0583	Boulevard	136	12
TQ0557	Boulevard	236	58
TQ0573	Boulevard	241	21
TQ0530	Boulevard	314	161
TQ0591	Boulevard	315	254
TQ0605	Boulevard	413	51
TQ0599	Boulevard	415	127
TQ0558	Boulevard	433	50
TQ0528	Boulevard	478	197
TQ0568	Boulevard	521	90
TQ0561	Boulevard	599	259
TQ0545	Boulevard	599	704
TQ0584	Boulevard	609	49
TQ0564	Boulevard	659	159
TQ0535	Boulevard	719	23
TQ0596	Boulevard	721	68
TQ0520	Boulevard	728	203
TQ0577	Boulevard	728	106
TQ0570	Boulevard	731	226
TQ0562	Boulevard	861	46
TQ0553	Boulevard	865	186
TQ0551	Boulevard	875	143
TQ0552	Boulevard	937	226
TQ0533	Boulevard	1012	263
TQ0534	**Boulevard**	**1103**	**604**
TQ0515	**Boulevard**	**1250**	**104**
TQ0511	**Boulevard**	**1285**	**492**
TQ0522	**Boulevard**	**1398**	**588**
TQ0539	**Boulevard**	**1470**	**233**
TQ0526	**Boulevard**	**1513**	**179**
TQ0567	**Boulevard**	**2067**	**861**
TQ0503	**Boulevard**	**2527**	**630**
TQ0509	**Boulevard**	**3153**	**1062**
TQ0501	**Boulevard**	**4943**	**907**
TQ0581	Cemetery	179	101
TQ0574	Cemetery	347	32
TQ0606	Residence	505	247
TQ0601	Residence	899	272
TQ0541	Park/Playground	54	2
TQ0604	Park/Playground	55	9
TQ0536	Park/Playground	88	23
TQ0603	Park/Playground	95	9
TQ0602	Park/Playground	109	25
TQ0580	Park/Playground	135	12
TQ0600	Park/Playground	147	107
TQ0585	Park/Playground	203	22
TQ0542	Park/Playground	220	172
TQ0575	Park/Playground	264	48
TQ0548	Park/Playground	289	251
TQ0565	Park/Playground	307	130
TQ0519	Park/Playground	352	67
TQ0586	Park/Playground	405	320
TQ0571	Park/Playground	472	200
TQ0550	Park/Playground	474	91
TQ0578	Park/Playground	530	101
TQ0527	Park/Playground	563	199
TQ0507	Park/Playground	590	213
TQ0576	Park/Playground	599	36
TQ0579	Park/Playground	614	141
TQ0595	Park/Playground	620	44
TQ0560	Park/Playground	642	89
TQ0566	Park/Playground	643	223
TQ0510	Park/Playground	764	572
TQ0588	Park/Playground	773	351
TQ0547	Park/Playground	777	471
TQ0531	Park/Playground	790	467
TQ0559	Park/Playground	876	131
TQ0543	Park/Playground	967	179
TQ0587	Park/Playground	997	244
TQ0563	Park/Playground	1007	507
TQ0549	**Park/Playground**	**1230**	**313**
TQ0525	**Park/Playground**	**1525**	**917**
TQ0592	**Park/Playground**	**1950**	**520**
TQ0514	**Park/Playground**	**2953**	**739**
TQ0521	Golf Course	918	149
TQ0506	Golf Course	1019	153
TQ0523	**Golf Course**	**2037**	**1046**
TQ0597	Vacant Land	285	32
TQ0524	Vacant Land	341	37
TQ0590	Vacant Land	474	281
TQ0529	Vacant Land	592	74
TQ0582	Vacant Land	617	231
TQ0532	Vacant Land	675	151
TQ0569	Vacant Land	853	105
TQ0556	Vacant Land	955	173
TQ0513	**Vacant Land**	**1593**	**81**
TQ0502	**Vacant Land**	**1970**	**209**
TQ0572	Vacant Land (undeveloped)	474	187
TQ0594	Vacant Land (undeveloped)	567	182
TQ0512	**Vacant Land (undeveloped)**	**1185**	**320**
TQ0516	**Vacant Land (undeveloped)**	**1317**	**568**
TQ0544	**Vacant Land (undeveloped)**	**1683**	**416**
TQ0546	**Vacant Land (undeveloped)**	**1740**	**754**
TQ0540	**Vacant Land (undeveloped)**	**1927**	**747**
TQ0505	**Vacant Land (undeveloped)**	**2010**	**455**
TQ0504	**Vacant Land (undeveloped)**	**2177**	**386**
TQ0518	**Vacant Land (undeveloped)**	**2560**	**350**
TQ0538	**Vacant Land (undeveloped)**	**2780**	**1058**
TQ0537	**Vacant Land (undeveloped)**	**4000**	**966**
TQ0508	**Vacant Land (undeveloped)**	**5103**	**484**
TQ0593	School yard	57	10
TQ0555	School yard	108	38
TQ0589	School yard	273	157
TQ0517	School yard	399	294
TQ0598	School yard	412	134
TQ0554	School yard	673	344
TQ0607	Park/Playground (Bakers Narrows)	90	40
TQ0608	Park/Playground (Cranberry Portage)	26	9

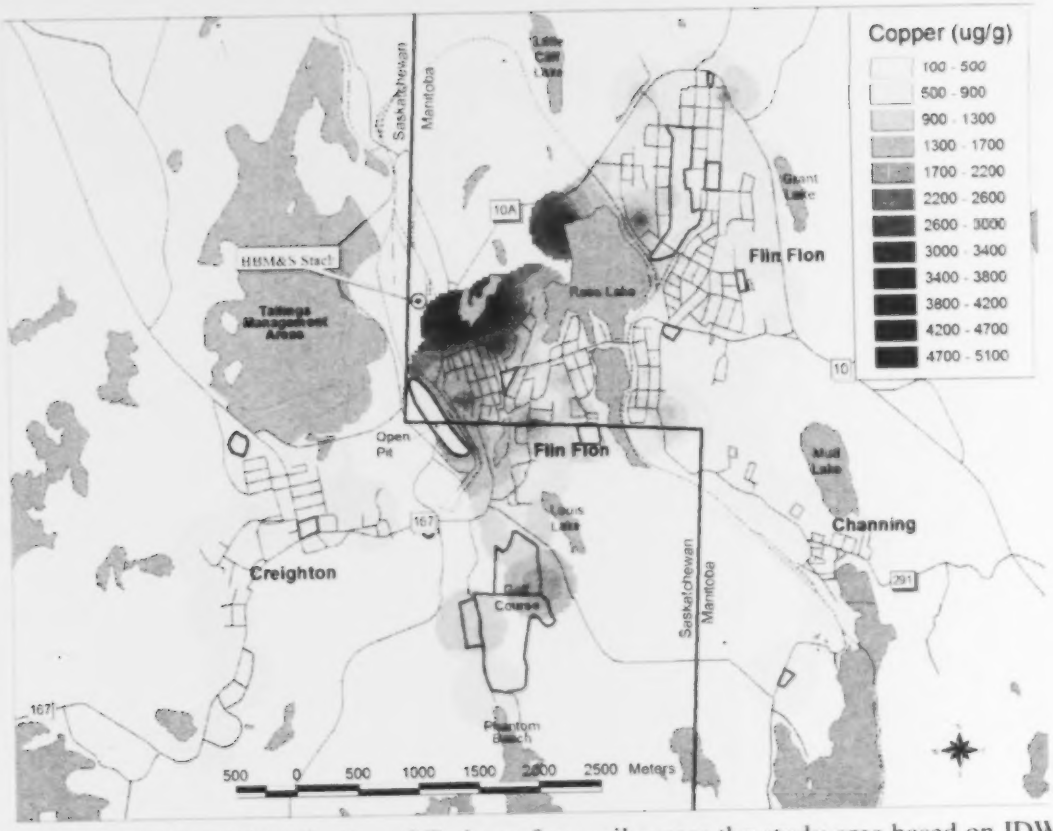


Figure 9. Projected distribution of Cu in surface soil across the study area based on IDW interpolation of the mean Cu concentrations at 106 sample sites.

The guideline for Cu for the protection of human health in residential/parkland soil is 1100 µg/g (CCME 1999). This guideline is high relative to most of the other elements under discussion and reflects the low toxicity of Cu to humans. Copper is actually a micro-nutrient and is required for proper growth and development in humans (Wood 2001), and only becomes toxic at very high levels of exposure (WHO 1998, CCME 1999). Twenty-eight (26 %) of the 106 sites sampled across Flin Flon and Creighton exceeded the guideline (Table 6). All of these sites were in Flin Flon, and the majority of them were located on undisturbed vacant lands (11 sites) and boulevards (9 sites). None of the school yard sites exceeded the guideline, and mean concentrations at only four (11 %) of the 36 parks/playgrounds sampled were above the guideline.

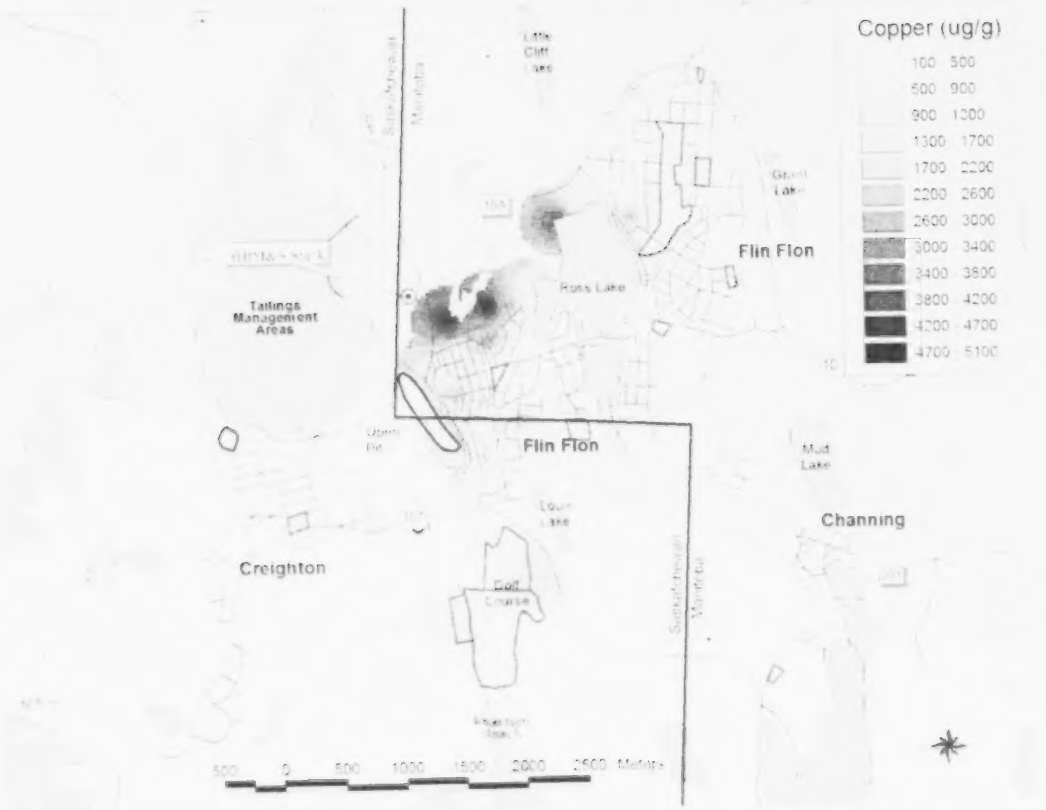


Figure 9. Projected distribution of Cu in surface soil across the study area based on IDW interpolation of the mean Cu concentrations at 106 sample sites.

The guideline for Cu for the protection of human health in residential/parkland soil is 1100 µg/g (CCME 1999). This guideline is high relative to most of the other elements under discussion and reflects the low toxicity of Cu to humans. Copper is actually a micro-nutrient and is required for proper growth and development in humans (Wood 2001), and only becomes toxic at very high levels of exposure (WHO 1998, CCME 1999). Twenty-eight (26 %) of the 106 sites sampled across Flin Flon and Creighton exceeded the guideline (Table 6). All of these sites were in Flin Flon, and the majority of them were located on undisturbed vacant lands (11 sites) and boulevards (9 sites). None of the school yard sites exceeded the guideline, and mean concentrations at only four (11 %) of the 36 parks/playgrounds sampled were above the guideline.

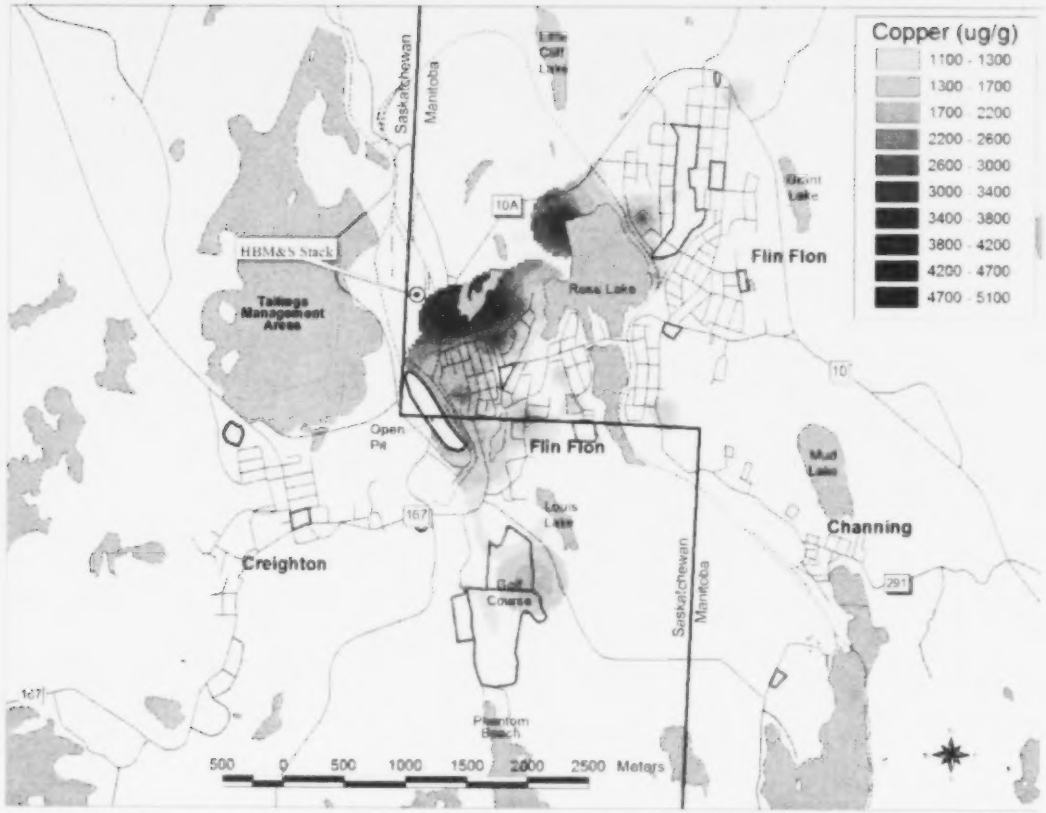


Figure 10. Projected distribution of Cu concentrations above the guideline level of 1100 µg/g in surface soil across the study area based on IDW interpolation of the mean Cu concentrations at 106 sample sites.

Lead (Pb)

Mean concentrations of Pb at sites in Flin Flon ranged from 5.0 µg/g to 1446.7 µg/g, while the range in concentrations in Creighton was considerably lower at 6.3 µg/g to 250.0 µg/g (Table 7). The overall mean concentration of all the sites in Flin Flon was 196.4 µg/g, whereas the overall mean for the sites in Creighton was roughly half that amount (92.5 µg/g). Mean concentrations at Bakers Narrows and Cranberry Portage were below any of the mean concentrations at sites in Flin Flon and Creighton. The highest concentrations of Pb within the study area were found in soil collected from undeveloped vacant parcels of land (Table 7). Like most of the other elements analyzed, the standard deviation of the mean concentration of Pb at several sites was high (i.e. often greater than 50 % of the mean), and reflects the relatively high degree of within-site variability present at many of the sites sampled.

Table 7. Mean concentrations of Pb in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. Sites in bold exceeded the residential/parkland human health protection guideline for Pb (140 µg/g). Creighton sites are enclosed in borders. (n = 3, S.D. = standard deviation).

Site	Site Type	Pb (ug/g)	S.D.
TQ0583	Boulevard	30.2	1.9
TQ0573	Boulevard	34.0	2.3
TQ0557	Boulevard	43.2	5.0
TQ0530	Boulevard	48.9	22.1
TQ0591	Boulevard	51.5	34.6
TQ0599	Boulevard	56.2	6.5
TQ0558	Boulevard	58.0	5.0
TQ0545	Boulevard	62.5	64.7
TQ0605	Boulevard	74.1	3.8
TQ0577	Boulevard	85.2	5.0
TQ0561	Boulevard	97.3	38.0
TQ0515	Boulevard	104.6	11.7
TQ0568	Boulevard	106.6	29.2
TQ0564	Boulevard	110.8	14.4
TQ0570	Boulevard	116.7	18.7
TQ0535	Boulevard	119.7	17.6
TQ0520	Boulevard	122.1	29.6
TQ0562	Boulevard	126.7	6.8
TQ0528	Boulevard	139.0	84.5
TQ0584	**Boulevard**	**141.3**	**22.5**
TQ0553	**Boulevard**	**146.0**	**32.9**
TQ0552	**Boulevard**	**150.7**	**32.6**
TQ0522	**Boulevard**	**157.7**	**45.0**
TQ0533	**Boulevard**	**159.3**	**26.6**
TQ0551	**Boulevard**	**169.0**	**30.8**
TQ0534	**Boulevard**	**171.0**	**141.2**
TQ0596	**Boulevard**	**175.3**	**11.6**
TQ0526	**Boulevard**	**191.0**	**32.0**
TQ0511	**Boulevard**	**216.0**	**70.7**
TQ0567	**Boulevard**	**227.0**	**77.3**
TQ0539	**Boulevard**	**236.7**	**99.6**
TQ0503	**Boulevard**	**303.7**	**63.4**
TQ0509	**Boulevard**	**452.7**	**157.8**
TQ0501	**Boulevard**	**535.7**	**31.1**
TQ0581	Cemetery	30.8	10.7
TQ0574	Cemetery	51.4	7.8
TQ0601	**Residence**	**146.7**	**48.0**
TQ0606	**Residence**	**159.7**	**69.0**
TQ0604	Park/Playgroutd	6.3	0.4
TQ0541	Park/Playground	11.2	1.7
TQ0536	Park/Playground	11.5	1.5
TQ0603	Park/Playground	17.6	1.4
TQ0602	Park/Playground	20.3	8.4
TQ0580	Park/Playground	21.6	5.7
TQ0600	Park/Playground	23.3	21.3
TQ0542	Park/Playground	31.2	32.6
TQ0585	Park/Playground	32.1	6.3
TQ0565	Park/Playground	51.0	18.2
TQ0575	Park/Playground	51.8	14.9
TQ0548	Park/Playground	53.7	28.6
TQ0579	Park/Playground	63.9	16.4
TQ0519	Park/Playground	65.2	15.7
TQ0578	Park/Playground	66.2	6.3
TQ0576	Park/Playground	71.2	4.2
TQ0571	Park/Playground	76.8	32.2
TQ0586	Park/Playground	85.3	72.7
TQ0507	Park/Playground	89.9	36.6
TQ0588	Park/Playground	91.4	45.9
TQ0510	Park/Playground	98.8	74.8
TQ0550	Park/Playground	103.6	38.6
TQ0560	Park/Playground	108.9	15.2
TQ0543	Park/Playground	113.0	19.1
TQ0527	Park/Playground	119.4	58.5
TQ0595	Park/Playground	119.7	11.7
TQ0531	Park/Playground	122.1	65.6
TQ0566	Park/Playground	123.2	80.4
TQ0563	Park/Playground	125.2	71.3
TQ0587	Park/Playground	126.8	57.6
TQ0592	Park/Playground	130.6	29.5
TQ0559	**Park/Playground**	**170.0**	**55.1**
TQ0525	**Park/Playground**	**171.0**	**83.6**
TQ0547	**Park/Playground**	**201.6**	**176.3**
TQ0514	**Park/Playground**	**216.3**	**43.1**
TQ0549	**Park/Playground**	**372.7**	**281.7**
TQ0521	**Golf Course**	**252.7**	**29.8**
TQ0506	**Golf Course**	**334.3**	**15.4**
TQ0523	**Golf Course**	**491.0**	**138.0**
TQ0524	Vacant Land	39.0	2.0
TQ0597	Vacant Land	75.5	33.6
TQ0532	Vacant Land	87.8	24.9
TQ0529	Vacant Land	93.7	3.2
TQ0502	Vacant Land	134.7	16.6
TQ0582	**Vacant Land**	**209.7**	**142.6**
TQ0590	**Vacant Land**	**217.6**	**170.0**
TQ0556	**Vacant Land**	**276.3**	**25.1**
TQ0569	**Vacant Land**	**281.3**	**217.2**
TQ0513	**Vacant Land**	**313.3**	**24.6**
TQ0572	Vacant Land (undeveloped)	136.8	89.8
TQ0504	**Vacant Land (undeveloped)**	**247.7**	**79.1**
TQ0540	**Vacant Land (undeveloped)**	**249.3**	**49.6**
TQ0594	**Vacant Land (undeveloped)**	**250.0**	**92.6**
TQ0512	**Vacant Land (undeveloped)**	**253.7**	**64.3**
TQ0516	**Vacant Land (undeveloped)**	**274.7**	**177.8**
TQ0546	**Vacant Land (undeveloped)**	**604.3**	**240.8**
TQ0544	**Vacant Land (undeveloped)**	**639.7**	**111.4**
TQ0518	**Vacant Land (undeveloped)**	**734.0**	**81.5**
TQ0508	**Vacant Land (undeveloped)**	**835.7**	**249.4**
TQ0537	**Vacant Land (undeveloped)**	**925.3**	**274.5**
TQ0538	**Vacant Land (undeveloped)**	**959.3**	**486.8**
TQ0505	**Vacant Land (undeveloped)**	**1446.7**	**471.8**
TQ0593	School yard	5.0	0.3
TQ0555	School yard	16.1	4.8
TQ0589	School yard	32.4	16.8
TQ0517	School yard	44.0	26.3
TQ0598	School yard	77.6	22.4
TQ0554	**School yard**	**155.3**	**51.8**
TQ0607	Park/Playground (Bakers Narrows)	21.9	8.1
TQ0608	Park/Playground (Cranberry Portage)	5.3	0.9

It is notable that the range in Pb at boulevard sites in Flin Flon in 2006 (30 µg/g to 536 µg/g) was lower than the range of 90 µg/g to 750 µg/g recorded at boulevard sites during the 1982 study by Jones (1983). As well, the overall mean of the 23 boulevard sites sampled in 1982 was 357 µg/g and the median was 280 µg/g, while the mean of the 34 boulevard sites sampled in the present study was 152 µg/g and the median was 127 µg/g. This comparison suggests that the Pb content of boulevard soils in Flin Flon has decreased significantly since 1982. However, this

interpretation must be treated with some caution since the precise locations sampled and the laboratory methods used differed between surveys.

Interpolation and mapping of the data indicates that Pb concentrations may be highest in soils in the west-central and northeastern areas of Flin Flon and lowest in the largely residential eastern portion of Flin Flon and in the community of Creighton (Figure 11). Lead concentrations in boulevard soils in 1982 showed a similar distribution, with the lowest concentrations generally found at sites in the residential eastern half of the community (Jones 1983)

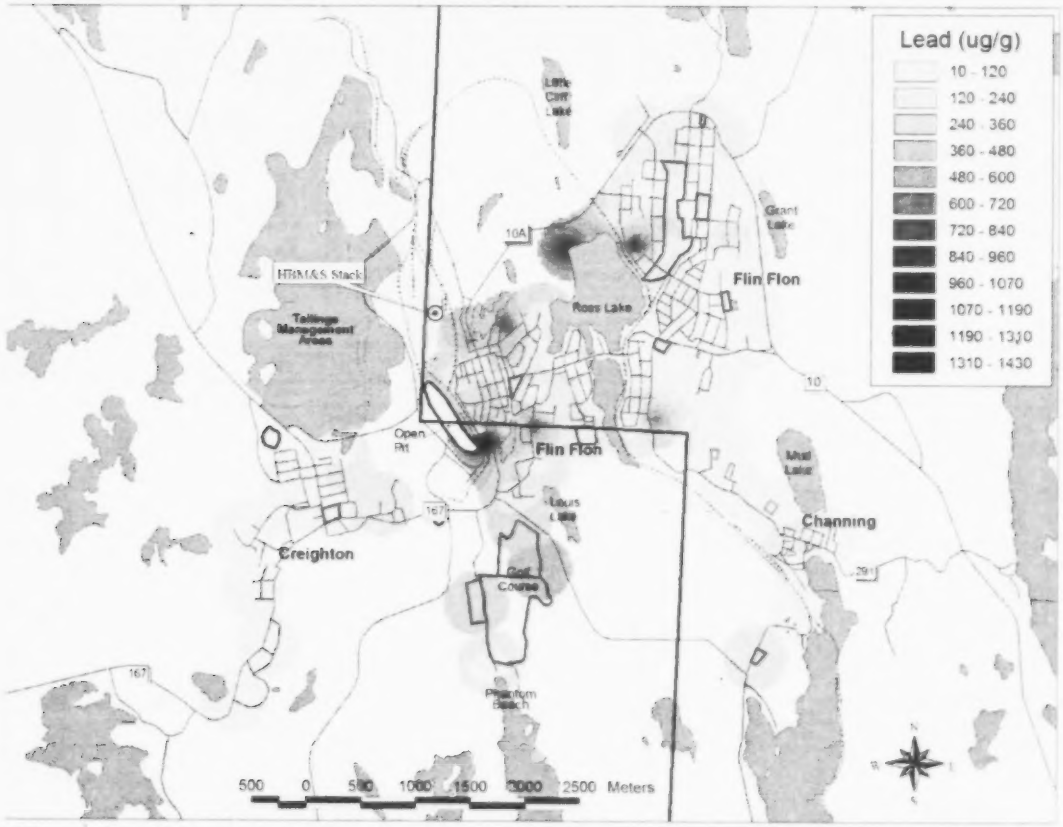


Figure 11. Projected distribution of Pb in surface soil across the study area based on IDW interpolation of the mean Pb concentrations at 106 sample sites.

The chemistry and toxicity of Pb in the environment, although complex, is fairly well understood, and the negative impacts to human health from exposure to excessive amounts of Pb are well-documented (CCME 1999, WHO 2000). The CCME human health protection guideline for Pb in soil intended for residential/parkland use is 140 µg/g (CCME 1999). This guideline is

very conservative and is derived to minimize impacts to human health from ingesting soil containing Pb. In the case of Pb, the human health guideline is also the overall soil quality guideline for the metal because it is lower than the environmental health guideline. The guideline was exceeded at 43 (41 %) of the sites sampled (Table 7). This included 39 sites in Flin Flon and 4 sites in Creighton. The guideline was most frequently exceeded at sites located on undeveloped land sites (12 of 13 sites), boulevards (14 of 34 sites), and vacant lots (5 of 10 sites). Only five park/playground sites and one school yard site had concentrations above the guideline; all of these were located in Flin Flon. The interpolation and mapping results suggest that much of the soil in Flin Flon, particularly in the older neighbourhoods near the smelter and in some areas northeast of the smelter, may have levels of Pb above the guideline (Figure 12).

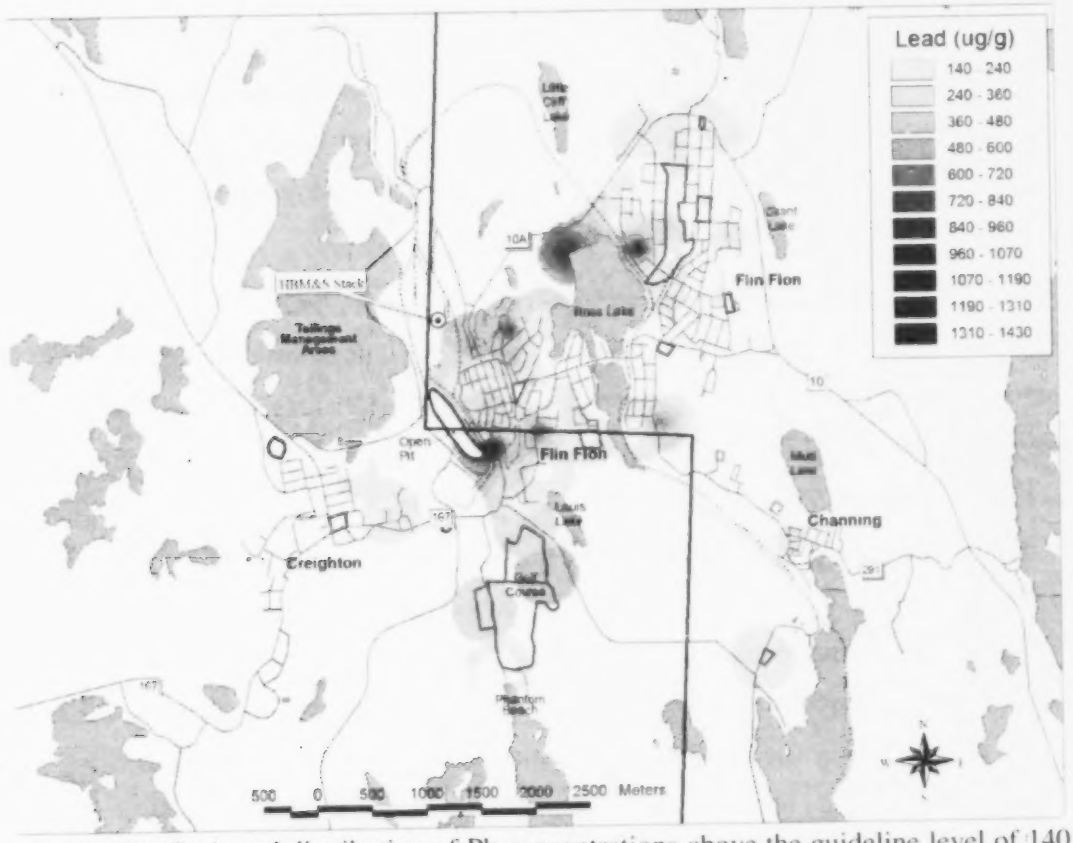


Figure 12. Projected distribution of Pb concentrations above the guideline level of 140 µg/g in surface soil across the study area based on IDW interpolation of the mean Pb concentrations at 106 sample sites.

interpretation must be treated with some caution since the precise locations sampled and the laboratory methods used *differed between surveys*.

Interpolation and mapping of the data indicates that Pb concentrations may be highest in soils in the west-central and northeastern areas of Flin Flon and lowest in the largely residential eastern portion of Flin Flon and in the community of Creighton (Figure 11). Lead concentrations in boulevard soils in 1982 showed a similar distribution, with the lowest concentrations generally found at sites in the residential eastern half of the community (Jones 1983).

Figure 11. Projected distribution of Pb in surface soil across the study area based on IDW interpolation of the mean Pb concentrations at 106 sample sites.

The chemistry and toxicity of Pb in the environment, although complex, is fairly well understood, and the negative impacts to human health from exposure to excessive amounts of Pb are well-documented (CCME 1999, WHO 2000). The CCME human health protection guideline for Pb in soil intended for residential/parkland use is 140 µg/g (CCME 1999). This guideline is

very conservative and is derived to minimize impacts to human health from ingesting soil containing Pb. In the case of Pb, the human health guideline is also the overall soil quality guideline for the metal because it is lower than the environmental health guideline. The guideline was exceeded at 43 (41 %) of the sites sampled (Table 7). This included 39 sites in Flin Flon and 4 sites in Creighton. The guideline was most frequently exceeded at sites located on undeveloped land sites (12 of 13 sites), boulevards (14 of 34 sites), and vacant lots (5 of 10 sites). Only five park/playground sites and one school yard site had concentrations above the guideline; all of these were located in Flin Flon. The interpolation and mapping results suggest that much of the soil in Flin Flon, particularly in the older neighbourhoods near the smelter and in some areas northeast of the smelter, may have levels of Pb above the guideline (Figure 12).

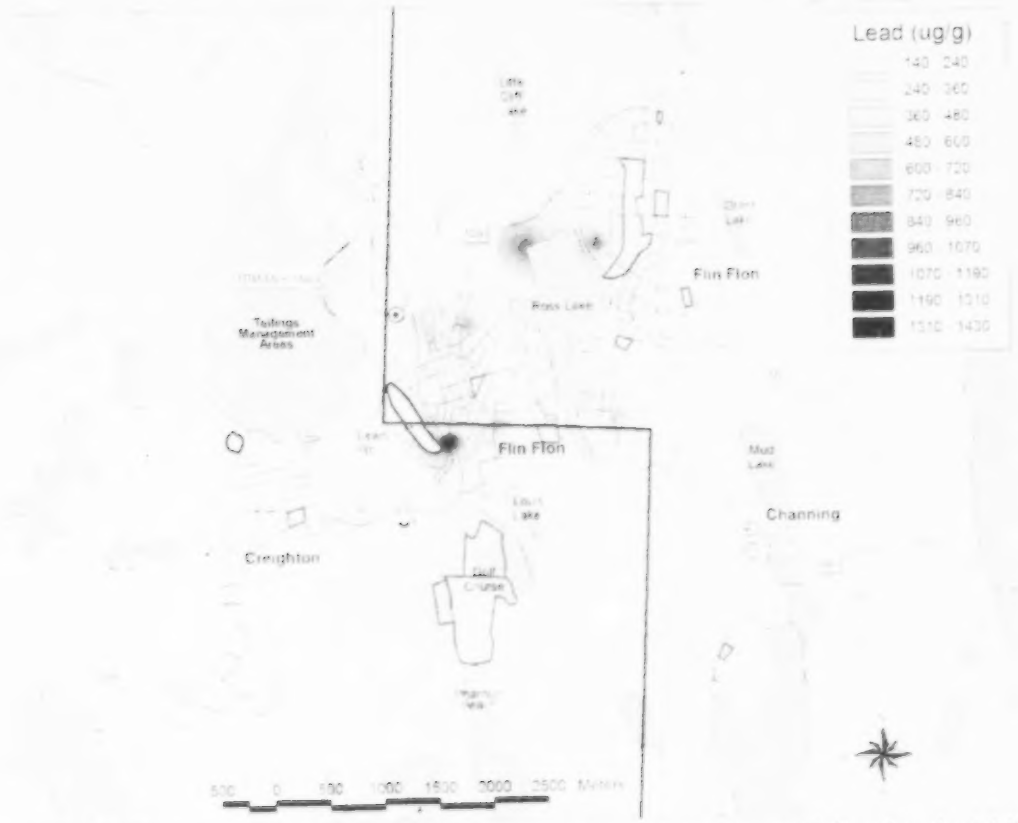


Figure 12. Projected distribution of Pb concentrations above the guideline level of 140 µg/g in surface soil across the study area based on IDW interpolation of the mean Pb concentrations at 106 sample sites.

Mercury (Hg)

Mean concentrations of Hg in Flin Flon ranged from 0.06 µg/g at a park/playground site in the northeast to 653.0 µg/g at a boulevard site near the smelter. The lowest concentration in Creighton, also 0.06 µg/g, was measured at a park/playground site in the south end of the community, while the highest concentration of 14.6 µg/g was recorded at a boulevard site in the northeast. As with most other elements of concern, the highest concentrations of Hg were usually found at sites situated on undeveloped lands and on boulevards (Table 8). Several park/playground sites, as well as the sites located on the golf course, also had relatively high concentrations of Hg. Although levels of Hg were high at several locations (particularly when compared to levels at the background sites in Bakers Narrows Provincial Park and in Cranberry Portage), mean concentrations at 79 of the 106 sites within the Flin Flon–Creighton study area were less than 20 µg/g.

In general, sites with the highest concentrations of Hg were located in the older core area of Flin Flon rather than in the more recently developed and/or more distant (from the smelter) neighbourhoods in the eastern half of the community and in Channing and Creighton. This pattern is clear in the interpolation results shown in Figure 13.

The CCME human health protection guideline for Hg in residential/parkland soils is 6.6 µg/g (CCME 1999). This guideline is directed at protecting human health based on the risk of ingesting inorganic Hg, since, like As, inorganic forms of the metal are more toxic to humans than organic forms (CCME 1999). This human health protection guideline is lower than the environmental protection guideline (12 µg/g) and is therefore the soil quality guideline for the metal in soil. The guideline was exceeded at 54 of the sites sampled (Table 8). Fifty-two of these sites were in Flin Flon and two were in Creighton. The guideline was exceeded at all but two of the 13 undeveloped land sites, half of the boulevard and vacant land sites, and 14 of the 36 park/playground sites. Mercury levels at two of the school yard sites, both located in Flin Flon, also exceeded the guideline. The interpolation and mapping results indicate that surface soils across much of Flin Flon may have concentrations of Hg above the guideline level, but this appears not to be the case for soils in Creighton and Channing (Figure 14).

Table 8. Mean concentrations of Hg in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. Sites in bold exceeded the residential/parkland human health protection guideline for Hg (6.6 µg/g). Creighton sites are enclosed in borders. (n = 3, S.D. = standard deviation).

Site	Site Type	Hg (ug/g)	S.D.
TQ0573	Boulevard	0.18	0.03
TQ0583	Boulevard	0.36	0.14
TQ0557	Boulevard	1.36	1.36
TQ0558	Boulevard	1.56	0.35
TQ0545	Boulevard	1.90	2.55
TQ0599	Boulevard	1.90	1.39
TQ0530	Boulevard	2.12	0.46
TQ0591	Boulevard	2.60	1.96
TQ0605	Boulevard	2.81	3.46
TQ0534	Boulevard	4.26	4.11
TQ0561	Boulevard	4.49	2.38
TQ0577	Boulevard	4.57	1.71
TQ0568	Boulevard	4.80	2.13
TQ0520	Boulevard	5.00	2.39
TQ0584	Boulevard	5.33	0.77
TQ0567	Boulevard	5.98	1.30
TQ0515	**Boulevard**	**7.28**	**1.49**
TQ0570	**Boulevard**	**7.32**	**1.42**
TQ0528	**Boulevard**	**7.88**	**7.53**
TQ0564	**Boulevard**	**7.95**	**1.79**
TQ0535	**Boulevard**	**9.77**	**2.52**
TQ0553	**Boulevard**	**10.87**	**3.07**
TQ0526	**Boulevard**	**12.16**	**2.64**
TQ0552	**Boulevard**	**14.05**	**4.27**
TQ0596	**Boulevard**	**14.60**	**4.97**
TQ0562	**Boulevard**	**17.25**	**13.23**
TQ0551	**Boulevard**	**17.73**	**3.21**
TQ0533	**Boulevard**	**22.03**	**8.57**
TQ0539	**Boulevard**	**31.37**	**15.37**
TQ0522	**Boulevard**	**31.60**	**13.53**
TQ0511	**Boulevard**	**59.67**	**25.09**
TQ0503	**Boulevard**	**146.10**	**58.36**
TQ0509	**Boulevard**	**358.00**	**96.44**
TQ0501	**Boulevard**	**653.00**	**370.31**
TQ0581	Cemetery	0.65	0.46
TQ0574	Cemetery	0.91	0.08
TQ0606	Residence	6.37	4.10
TQ0601	**Residence**	**6.90**	**1.87**

Site	Site Type	Hg (ug/g)	S.D.
TQ0604	Park/Playground	0.06	0.02
TQ0536	Park/Playground	0.06	0.01
TQ0541	Park/Playground	0.07	0.01
TQ0603	Park/Playground	0.08	0.00
TQ0602	Park/Playground	0.23	0.16
TQ0580	Park/Playground	0.62	0.50
TQ0600	Park/Playground	1.10	1.23
TQ0585	Park/Playground	1.21	0.82
TQ0542	Park/Playground	2.07	3.25
TQ0579	Park/Playground	2.29	0.27
TQ0548	Park/Playground	2.64	3.23
TQ0586	Park/Playground	2.97	2.31
TQ0575	Park/Playground	3.33	1.02
TQ0507	Park/Playground	3.67	2.63
TQ0578	Park/Playground	3.86	1.90
TQ0550	Park/Playground	4.05	2.18
TQ0595	Park/Playground	4.07	0.45
TQ0565	Park/Playground	4.33	3.00
TQ0571	Park/Playground	4.33	1.19
TQ0576	Park/Playground	4.33	0.54
TQ0566	Park/Playground	4.96	2.50
TQ0547	Park/Playground	5.71	4.32
TQ0563	**Park/Playground**	**7.17**	**5.31**
TQ0543	**Park/Playground**	**7.35**	**0.87**
TQ0519	**Park/Playground**	**7.72**	**4.03**
TQ0559	**Park/Playground**	**9.53**	**3.92**
TQ0560	**Park/Playground**	**9.55**	**2.34**
TQ0587	**Park/Playground**	**10.01**	**6.39**
TQ0588	**Park/Playground**	**12.31**	**11.75**
TQ0549	**Park/Playground**	**16.57**	**6.37**
TQ0527	**Park/Playground**	**20.17**	**10.14**
TQ0531	**Park/Playground**	**21.87**	**9.26**
TQ0592	**Park/Playground**	**27.30**	**1.91**
TQ0510	**Park/Playground**	**36.74**	**38.57**
TQ0525	**Park/Playground**	**37.33**	**22.17**
TQ0514	**Park/Playground**	**68.67**	**32.43**
TQ0506	**Golf Course**	**11.97**	**3.79**
TQ0521	**Golf Course**	**23.93**	**8.73**
TQ0523	**Golf Course**	**35.43**	**6.18**

Site	Site Type	Hg (ug/g)	S.D.
TQ0597	Vacant Land	1.97	1.86
TQ0524	Vacant Land	3.41	1.46
TQ0582	Vacant Land	4.10	0.50
TQ0569	Vacant Land	6.37	2.16
TQ0529	Vacant Land	6.59	1.53
TQ0590	**Vacant Land**	**8.34**	**10.23**
TQ0502	**Vacant Land**	**9.19**	**1.25**
TQ0556	**Vacant Land**	**10.38**	**2.63**
TQ0532	**Vacant Land**	**14.40**	**5.00**
TQ0513	**Vacant Land**	**51.83**	**6.81**
TQ0572	Vacant Land (undeveloped)	2.76	1.52
TQ0594	Vacant Land (undeveloped)	6.33	2.08
TQ0546	**Vacant Land (undeveloped)**	**20.22**	**10.04**
TQ0504	**Vacant Land (undeveloped)**	**20.76**	**12.38**
TQ0540	**Vacant Land (undeveloped)**	**24.67**	**4.48**
TQ0544	**Vacant Land (undeveloped)**	**27.10**	**7.22**
TQ0538	**Vacant Land (undeveloped)**	**31.40**	**6.93**
TQ0537	**Vacant Land (undeveloped)**	**60.10**	**28.73**
TQ0512	**Vacant Land (undeveloped)**	**61.87**	**27.39**
TQ0516	**Vacant Land (undeveloped)**	**73.43**	**58.79**
TQ0505	**Vacant Land (undeveloped)**	**78.33**	**33.01**
TQ0518	**Vacant Land (undeveloped)**	**87.57**	**7.01**
TQ0508	**Vacant Land (undeveloped)**	**562.00**	**72.02**
TQ0593	School yard	0.17	0.06
TQ0555	School yard	0.33	0.10
TQ0598	School yard	1.67	0.76
TQ0589	School yard	2.31	1.82
TQ0554	**School yard**	**9.98**	**8.42**
TQ0517	**School yard**	**12.83**	**17.06**
TQ0607	Park/Playground (Bakers Narrows)	0.27	0.05
TQ0608	Park/Playground (Cranberry Portage)	0.14	0.00

Figure 13. Projected distribution of Hg in surface soil across the study area based on IDW interpolation of the mean Hg concentrations at 106 sample sites.

The potential for relatively high levels of Hg in surface soils across Flin Flon may be a concern for some. However, it must be stressed that the Hg concentrations recorded in this study are total concentrations and the guideline of 6.6 µg/g is derived specifically for inorganic Hg. Thus, although a significant portion of the total Hg present in the soil may be inorganic, the actual amount can vary considerably depending on soil chemistry and physical properties. Characteristics such as clay and organic matter content, pH, and the concentration of other elements in the soil can influence the amount of inorganic Hg present (CCME 1999).

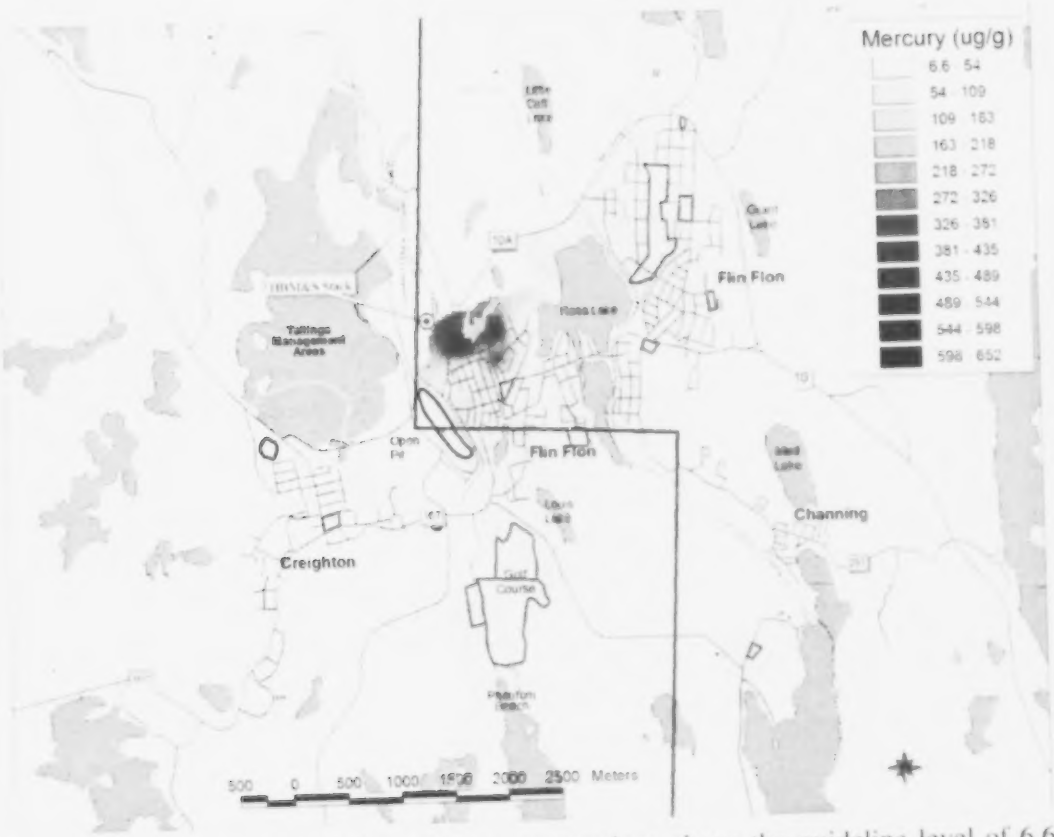


Figure 14. Projected distribution of Hg concentrations above the guideline level of 6.6 µg/g in surface soil across the study area based on IDW interpolation of the mean Hg concentrations at 106 sample sites.

Selenium (Se)

The highest mean concentration of Se (177.2 µg/g) was recorded at a boulevard site close to the smelter in Flin Flon, while the lowest concentrations, all less than detection (<0.2 µg/g), were recorded at a school yard site and a park/playground site in Flin Flon and at a park/playground site in Creighton (Table 9). The highest mean concentration in Creighton was 7.2 µg/g at a boulevard site in the northeast corner of the community. The majority of the sites in Flin Flon and Creighton had concentrations of Se above those of the sites in Cranberry Portage and Bakers Narrows. The highest concentrations tended to occur at sites located on undeveloped parcels of land and on boulevards. Most of these sites were located in older areas of Flin Flon immediately east and south of the smelter complex. Interpolation and mapping of the data

indicates that soils across much of this area of the community may have significantly elevated concentrations of Se relative to the rest of the study area (Figure 15).

Table 9. Mean concentrations of Se in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. Sites in bold exceeded the residential/parkland human health protection guideline for Se (28 µg/g). Creighton sites are enclosed in borders. (n = 3, S.D. = standard deviation).

Site	Site Type	Se (ug/g)	S.D.
TQ0557	Boulevard	0.8	
TQ0573	Boulevard	0.9	
TQ0580	Boulevard	0.9	
TQ0583	Boulevard	1.1	
TQ0591	Boulevard	1.5	
TQ0605	Boulevard	1.6	
TQ0545	Boulevard	1.8	
TQ0568	Boulevard	2.0	
TQ0528	Boulevard	2.2	
TQ0558	Boulevard	2.6	
TQ0561	Boulevard	2.7	
TQ0589	Boulevard	2.7	
TQ0577	Boulevard	3.0	
TQ0570	Boulevard	3.2	
TQ0534	Boulevard	3.3	
TQ0520	Boulevard	3.3	
TQ0564	Boulevard	3.5	
TQ0584	Boulevard	3.7	
TQ0515	Boulevard	4.0	
TQ0535	Boulevard	4.1	
TQ0562	Boulevard	4.2	
TQ0553	Boulevard	4.5	
TQ0551	Boulevard	5.4	
TQ0552	Boulevard	5.6	
TQ0567	Boulevard	5.7	
TQ0533	Boulevard	6.2	
TQ0586	Boulevard	7.2	
TQ0539	Boulevard	7.5	
TQ0522	Boulevard	7.8	
TQ0526	Boulevard	11.8	
TQ0511	Boulevard	14.3	
TQ0503	**Boulevard**	**54.1**	**20.1**
TQ0509	**Boulevard**	**76.4**	**25.1**
TQ0501	**Boulevard**	**177.2**	**94.2**
TQ0581	Cemetery	0.7	
TQ0574	Cemetery	1.3	
TQ0601	Residence	5.1	
TQ0606	Residence	5.3	
TQ0536	Park/Playground	< 0.2	
TQ0604	Park/Playground	< 0.2	
TQ0603	Park/Playground	0.2	
TQ0602	Park/Playground	0.3	
TQ0580	Park/Playground	0.4	
TQ0541	Park/Playground	0.5	
TQ0600	Park/Playground	0.7	
TQ0542	Park/Playground	1.0	
TQ0585	Park/Playground	1.1	
TQ0575	Park/Playground	1.8	
TQ0565	Park/Playground	1.8	
TQ0548	Park/Playground	1.9	
TQ0571	Park/Playground	2.1	
TQ0578	Park/Playground	2.1	
TQ0550	Park/Playground	2.2	
TQ0519	Park/Playground	2.6	
TQ0579	Park/Playground	2.6	
TQ0586	Park/Playground	2.7	
TQ0566	Park/Playground	2.9	
TQ0507	Park/Playground	3.1	
TQ0576	Park/Playground	3.1	
TQ0588	Park/Playground	3.9	
TQ0560	Park/Playground	4.0	
TQ0543	Park/Playground	4.2	
TQ0595	Park/Playground	4.2	
TQ0587	Park/Playground	4.3	
TQ0547	Park/Playground	4.3	
TQ0563	Park/Playground	4.5	
TQ0527	Park/Playground	4.9	
TQ0559	Park/Playground	5.0	
TQ0531	Park/Playground	5.8	
TQ0510	Park/Playground	7.5	
TQ0549	Park/Playground	7.6	
TQ0592	Park/Playground	8.1	
TQ0525	Park/Playground	11.1	
TQ0514	Park/Playground	18.0	
TQ0521	Golf Course	7.0	
TQ0506	Golf Course	8.4	
TQ0523	Golf Course	12.6	
TQ0524	Vacant Land	1.2	
TQ0597	Vacant Land	2.5	
TQ0580	Vacant Land	2.9	
TQ0529	Vacant Land	2.9	
TQ0582	Vacant Land	3.6	
TQ0532	Vacant Land	3.7	
TQ0569	Vacant Land	4.3	
TQ0556	Vacant Land	5.6	
TQ0502	Vacant Land	6.6	
TQ0513	Vacant Land	17.3	
TQ0572	Vacant Land (undeveloped)	2.0	
TQ0594	Vacant Land (undeveloped)	26.1	
TQ0504	Vacant Land (undeveloped)	10.3	
TQ0546	Vacant Land (undeveloped)	10.7	
TQ0544	Vacant Land (undeveloped)	12.4	
TQ0538	Vacant Land (undeveloped)	14.7	
TQ0540	Vacant Land (undeveloped)	14.9	
TQ0512	Vacant Land (undeveloped)	15.8	
TQ0516	Vacant Land (undeveloped)	15.9	
TQ0537	Vacant Land (undeveloped)	23.5	
TQ0518	Vacant Land (undeveloped)	26.2	
TQ0505	**Vacant Land (undeveloped)**	**37.9**	**12.3**
TQ0508	**Vacant Land (undeveloped)**	**129.0**	**6.6**
TQ0593	School yard	< 0.2	
TQ0555	School yard	0.5	
TQ0589	School yard	1.3	
TQ0598	School yard	1.9	
TQ0554	School yard	3.2	
TQ0517	School yard	3.9	
TQ0607	Park/Playground (Bakers Narrows)	0.7	
TQ0608	Park/Playground (Cranberry Portage)	0.2	

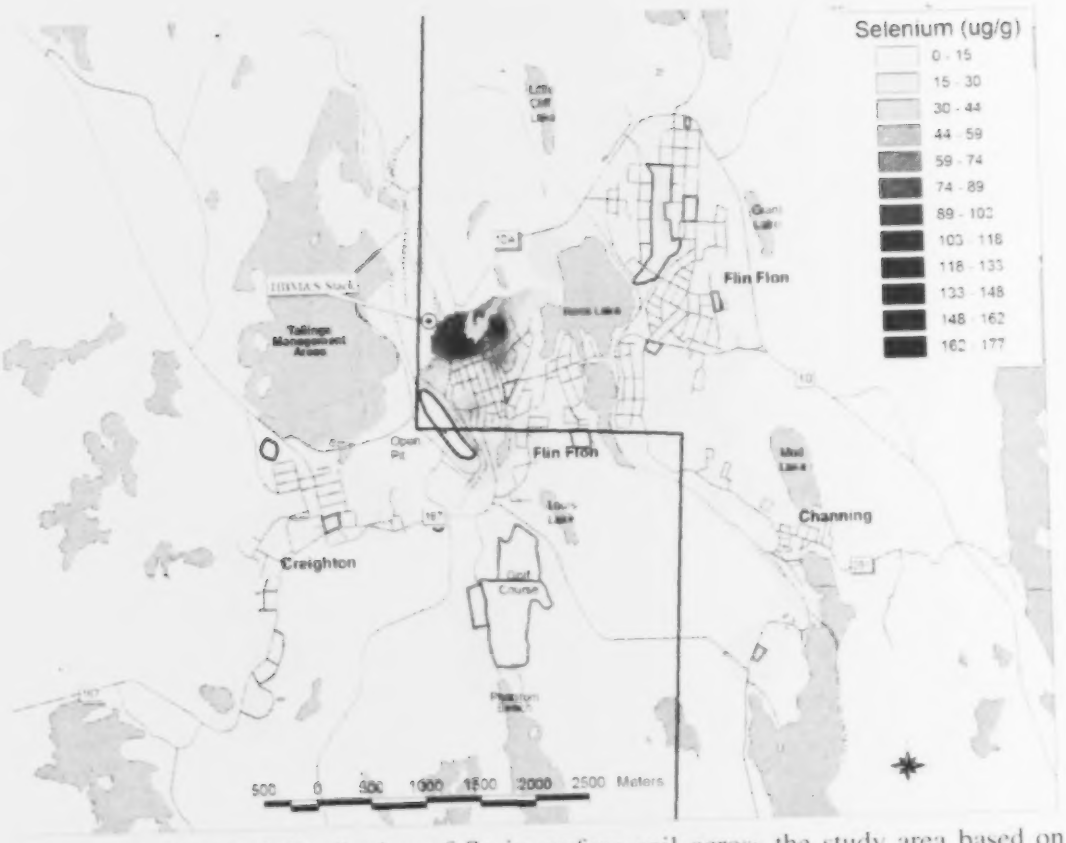


Figure 15. Projected distribution of Se in surface soil across the study area based on IDW interpolation of the mean Se concentrations at 106 sample sites.

Selenium is a micro-nutrient that is required in very small amounts for normal growth and development in humans. The recommended daily intake for humans is about 1 µg per kg of body weight (CCME 1999), or about 70 µg for the average adult. There is, however, a fine line between exposure levels that are safe and those that are hazardous. The CCME residential/parkland guideline for Se for the protection of human health is 28 µg/g (CCME 1999). This guideline takes into account that Se is a necessary component of a healthy diet and that the presence of Se in soil is acceptable when concentrations are low. Selenium concentrations in Flin Flon were above the guideline at three boulevard sites and at two sites located on vacant undeveloped land (Table 9). None of the sites sampled in Creighton exceeded the guideline. The sites that exceeded the guideline in Flin Flon were located in and around the downtown business district just east and south of the smelter complex. The interpolation results indicate that concentrations of Se in soils in this core area of the community might be above the

guideline (Figure 16). However, as with other soil constituents, landscaping and other alterations over time can influence the concentration of Se in soil, and areas that have been more recently landscaped are expected to have lower amounts of Se; possibly even below the guideline level.

Figure 16. Projected distribution of Se concentrations above the guideline level of 28 µg/g in surface soil across the study area based on IDW interpolation of the mean Se concentrations at 106 sample sites.

Thallium (Tl)

Mean concentrations of Tl were below detection (<0.1 µg/g) at 15 of the 106 sites sampled in Flin Flon and Creighton (Table 10). This included ten of the 36 parks/playgrounds and four of the six schoolyards. Detectable concentrations of Tl in surface soil were generally low across both communities. The majority of sites (69 %) had mean concentrations between 0.1 µg/g and 0.3 µg/g, which is generally within the range (0.19 µg/g to 0.6 µg/g) recorded in a 2004 survey

of Manitoba agricultural and forest soils (Smith *et al.* 2005). The highest concentrations of Tl were found at sites on vacant undeveloped land and boulevards in Flin Flon. Levels at the Bakers Narrows and Cranberry Portage sites suggest that background concentrations for the region are low.

Table 10. . Mean concentrations of Tl in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. Sites in bold exceeded the residential/parkland human health protection guideline for Tl (1.0 µg/g). Creighton sites are enclosed in borders. (n = 3, S.D. = standard deviation).

Site	Site Type	Tl (ug/g)	S.D.
TQ00545	Boulevard	< 0.1	
TQ00557	Boulevard	0.1	0.0
TQ00528	Boulevard	0.1	0.0
TQ00530	Boulevard	0.1	0.0
TQ00605	Boulevard	0.1	0.0
TQ00564	Boulevard	0.1	0.1
TQ00568	Boulevard	0.1	0.1
TQ00558	Boulevard	0.2	0.1
TQ00583	Boulevard	0.2	0.1
TQ00511	Boulevard	0.2	0.1
TQ00515	Boulevard	0.2	0.1
TQ00533	Boulevard	0.2	0.1
TQ00553	Boulevard	0.2	0.1
TQ00570	Boulevard	0.2	0.1
TQ00573	Boulevard	0.2	0.1
TQ00577	Boulevard	0.2	0.1
TQ00584	Boulevard	0.2	0.1
TQ00589	Boulevard	0.2	0.1
TQ00520	Boulevard	0.2	0.0
TQ00522	Boulevard	0.2	0.1
TQ00535	Boulevard	0.2	0.0
TQ00552	Boulevard	0.2	0.0
TQ00567	Boulevard	0.2	0.0
TQ00526	Boulevard	0.2	0.1
TQ00551	Boulevard	0.2	0.1
TQ00561	Boulevard	0.2	0.1
TQ00562	Boulevard	0.2	0.1
TQ00534	Boulevard	0.3	0.1
TQ00591	Boulevard	0.3	0.1
TQ00596	Boulevard	0.3	0.0
TQ00509	Boulevard	0.5	0.2
TQ00503	Boulevard	0.5	0.1
TQ00501	Boulevard	0.7	0.0
TQ00539	**Boulevard**	**1.2**	**1.3**
TQ00574	Cemetery	0.2	0.0
TQ00581	Cemetery	0.4	0.1
TQ00601	Residence	0.2	0.0
TQ00606	Residence	0.3	0.1
TQ00536	Park/Playground	< 0.1	
TQ00541	Park/Playground	< 0.1	
TQ00542	Park/Playground	< 0.1	
TQ00575	Park/Playground	< 0.1	
TQ00580	Park/Playground	< 0.1	
TQ00585	Park/Playground	< 0.1	
TQ00600	Park/Playground	< 0.1	
TQ00602	Park/Playground	< 0.1	
TQ00603	Park/Playground	< 0.1	
TQ00604	Park/Playground	< 0.1	
TQ00507	Park/Playground	0.1	0.0
TQ00519	Park/Playground	0.1	0.0
TQ00527	Park/Playground	0.1	0.0
TQ00543	Park/Playground	0.1	0.0
TQ00565	Park/Playground	0.1	0.0
TQ00571	Park/Playground	0.1	0.0
TQ00579	Park/Playground	0.1	0.0
TQ00563	Park/Playground	0.1	0.1
TQ00586	Park/Playground	0.2	0.1
TQ00525	Park/Playground	0.2	0.1
TQ00531	Park/Playground	0.2	0.1
TQ00566	Park/Playground	0.2	0.1
TQ00588	Park/Playground	0.2	0.1
TQ00595	Park/Playground	0.2	0.1
TQ00510	Park/Playground	0.2	0.0
TQ00514	Park/Playground	0.2	0.0
TQ00547	Park/Playground	0.2	0.2
TQ00548	Park/Playground	0.2	0.0
TQ00576	Park/Playground	0.2	0.0
TQ00587	Park/Playground	0.2	0.2
TQ00592	Park/Playground	0.2	0.0
TQ00560	Park/Playground	0.2	0.1
TQ00550	Park/Playground	0.3	0.1
TQ00559	Park/Playground	0.3	0.1
TQ00578	Park/Playground	0.3	0.1
TQ00549	Park/Playground	0.4	0.2
TQ00506	Golf Course	0.3	0.1
TQ00521	Golf Course	0.3	0.1
TQ00523	Golf Course	0.5	0.1
TQ00529	Vacant Land	0.1	0.1
TQ00532	Vacant Land	0.2	0.1
TQ00502	Vacant Land	0.2	0.0
TQ00569	Vacant Land	0.2	0.0
TQ00597	Vacant Land	0.2	0.1
TQ00524	Vacant Land	0.2	0.1
TQ00513	Vacant Land	0.3	0.1
TQ00582	Vacant Land	0.3	0.1
TQ00556	Vacant Land	0.3	0.1
TQ00590	Vacant Land	0.4	0.1
TQ00572	Vacant Land (undeveloped)	0.2	0.1
TQ00512	Vacant Land (undeveloped)	0.2	0.1
TQ00516	Vacant Land (undeveloped)	0.2	0.1
TQ00504	Vacant Land (undeveloped)	0.3	0.1
TQ00594	Vacant Land (undeveloped)	0.3	0.1
TQ00540	Vacant Land (undeveloped)	0.3	0.1
TQ00546	Vacant Land (undeveloped)	0.3	0.2
TQ00544	Vacant Land (undeveloped)	0.4	0.1
TQ00537	Vacant Land (undeveloped)	0.5	0.0
TQ00518	Vacant Land (undeveloped)	0.5	0.1
TQ00538	Vacant Land (undeveloped)	0.6	0.2
TQ00508	Vacant Land (undeveloped)	0.6	0.2
TQ00505	**Vacant Land (undeveloped)**	**1.0**	**0.1**
TQ00517	School yard	< 0.1	
TQ00555	School yard	< 0.1	
TQ00589	School yard	< 0.1	
TQ00593	School yard	< 0.1	
TQ00598	School yard	0.1	0.0
TQ00554	School yard	0.3	0.1
TQ00607	Park/Playground (Bakers Narrows)	0.1	0.0
TQ00608	Park/Playground (Cranberry Portage)	0.1	0.0

Thallium has a history of use as an ingredient in rat poison and insecticides (banned or restricted in many countries since the 1970s) and is known to be toxic to humans at relatively low concentrations (ATSDR 1992, CCME 1999). The human health protection guideline for Tl in residential/parkland soil is 1.0 µg/g (CCME 1999). The guideline was slightly exceeded in Flin Flon at a boulevard site near the eastern shore of Ross Lake and at an undeveloped vacant land site in the southwest corner of the community. There is the potential for elevated concentrations of the metal to be found elsewhere in soils that have had very prolonged exposure to atmospheric smelter emissions, such as undeveloped land and boulevards in older neighbourhoods near the smelter complex (Figure 17). However, based on these 2006 data, concentrations across most of the study area are likely well below the guideline of 1.0 µg/g

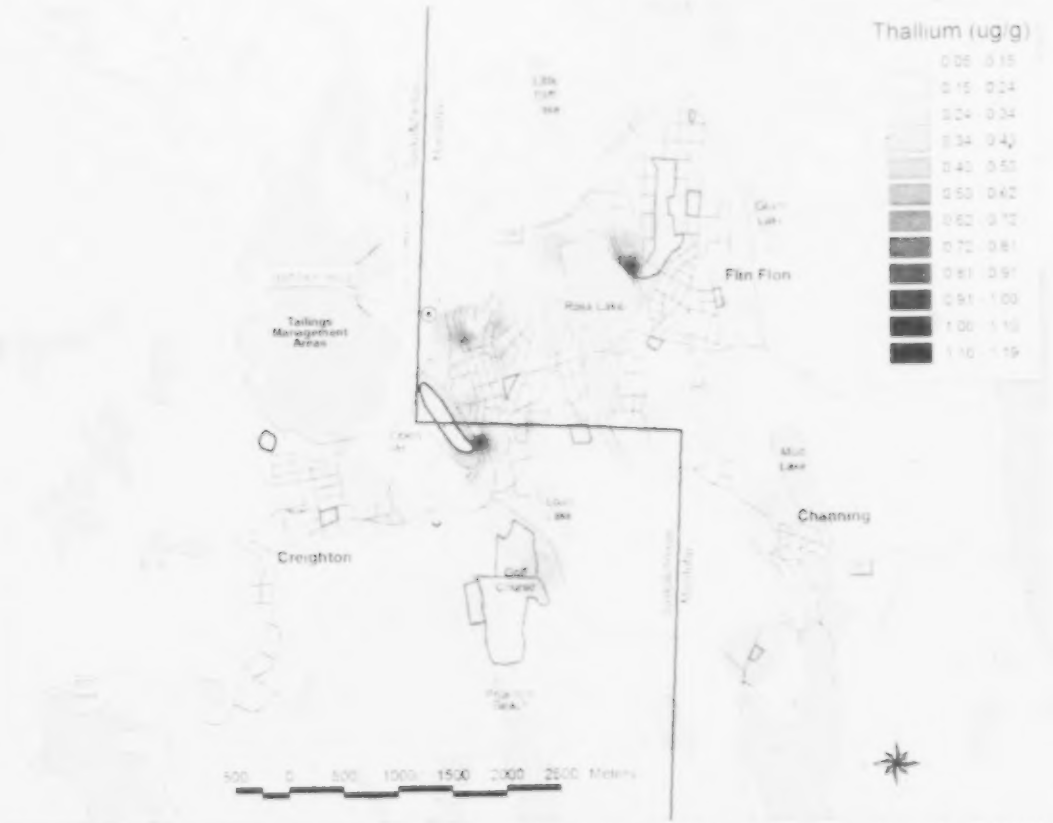


Figure 17. Projected distribution of Tl in surface soil across the study area based on IDW interpolation of the mean Tl concentrations at 106 sample sites. Note: a concentration of 0.05 µg/g was assigned to sites with concentrations less than detection (<0.1 µg/g) prior to interpolating the data.

Thallium has a history of use as an ingredient in rat poison and insecticides (banned or restricted in many countries since the 1970s) and is known to be toxic to humans at relatively low concentrations (ATSDR 1992, CCME 1999). The human health protection guideline for Tl in residential/parkland soil is 1.0 µg/g (CCME 1999). The guideline was slightly exceeded in Flin Flon at a boulevard site near the eastern shore of Ross Lake and at an undeveloped vacant land site in the southwest corner of the community. There is the potential for elevated concentrations of the metal to be found elsewhere in soils that have had very prolonged exposure to atmospheric smelter emissions, such as undeveloped land and boulevards in older neighbourhoods near the smelter complex (Figure 17). However, based on these 2006 data, concentrations across most of the study area are likely well below the guideline of 1.0 µg/g

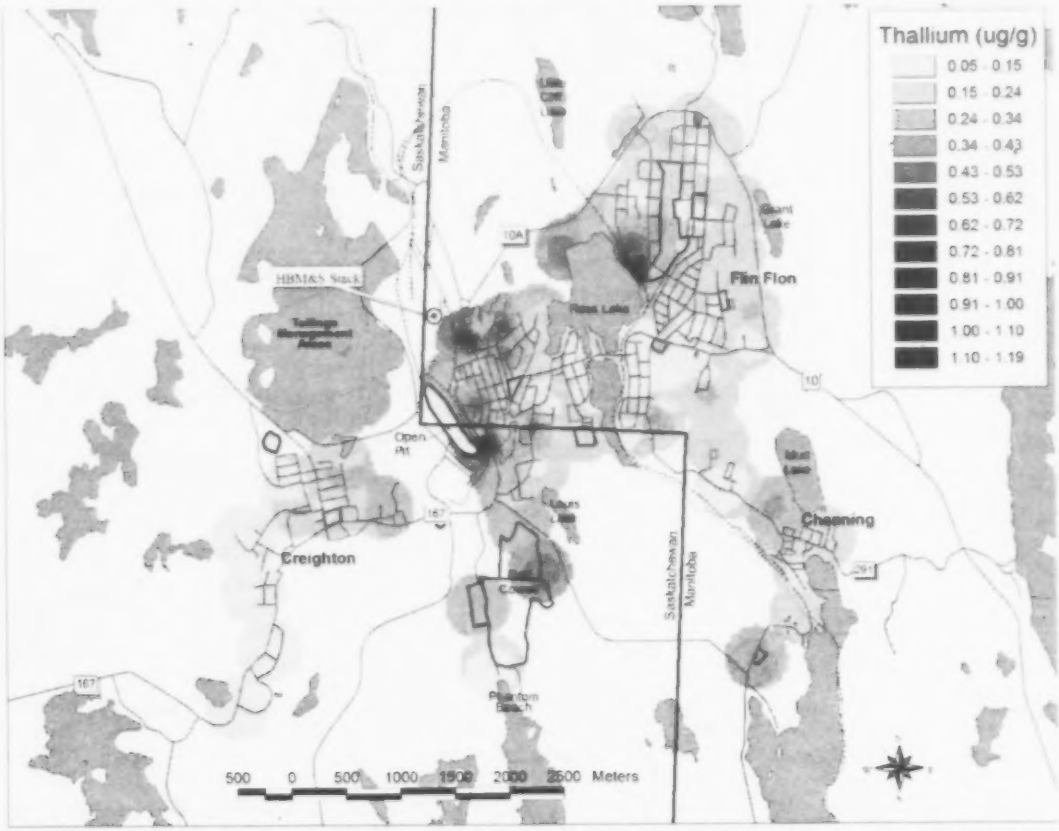


Figure 17. Projected distribution of Tl in surface soil across the study area based on IDW interpolation of the mean Tl concentrations at 106 sample sites. Note: a concentration of 0.05 µg/g was assigned to sites with concentrations less than detection (<0.1 µg/g) prior to interpolating the data.

Zinc (Zn)

Zinc concentrations were clearly elevated across Flin Flon and Creighton, particularly when compared to the mean concentration at the Cranberry Portage site (Table 11). Mean concentrations in Flin Flon ranged from 39 µg/g at a play area in a school yard to 11550 µg/g at an undeveloped site along the walking path at the north end of Ross Lake. The mean concentration for all Flin Flon sites was 2052 µg/g, while the median concentration was 1390 µg/g (that is, half of the sites had mean concentrations higher than 1390 µg/g). The range in mean concentrations in Creighton was considerably less; from a low of 55 µg/g at a playground site to a high of 1057 µg/g in soil from a residential lot. The highest concentrations of Zn tended to occur at sites located on undeveloped parcels of land. However, boulevards, vacant lots, and several park/playground sites also had relatively high concentrations of the metal (Table 11). Although results varied considerably with each land use category, the lowest concentrations tended to occur at sites located in parks/playgrounds and school yards. The interpolation and mapping results show that Zn levels are potentially at their highest in soils in the west, northeast, and central areas of Flin Flon and likely least concentrated in Creighton and in the east and southeast areas of Flin Flon (Figure 18).

Zinc is an important micronutrient required for growth and development in plants and animals. Excessive Zn can, however, negatively impact soil micro-fauna and nutrient cycling and therefore the CCME (1999) recommends a guideline of 200 µg/g for the protection of environmental health. Mean concentrations of Zn exceeded the guideline at all but seven park/playground sites, two school yard sites, and the Cranberry Portage site. In humans, Zn is a necessary component of numerous enzymes and dietary deficiencies can have impacts on health (ATSDR 2005). Zinc only becomes a health concern to humans if there is prolonged exposure to very high concentrations. For example, ingestion of amounts 10 – 15 times higher than the recommended daily intake of 8 to 11 mg for adults can lead to stomach cramps and nausea (ATSDR 2005). Since the toxicity of Zn is relatively low, no human health protection guidelines have been developed.

Table 11. Mean concentrations of Zn in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. Sites in bold exceeded the residential/parkland environmental health protection guideline for Zn (200 µg/g). Creighton sites are enclosed in borders. (n = 3, S.D. = standard deviation).

Site	Site Type	Zn (ug/g)	S.D.
TQ0583	**Boulevard**	**202**	13
TQ0573	**Boulevard**	**276**	54
TQ0530	**Boulevard**	**339**	115
TQ0605	**Boulevard**	**340**	31
TQ0557	**Boulevard**	**452**	120
TQ0591	**Boulevard**	**454**	270
TQ0528	**Boulevard**	**631**	287
TQ0599	**Boulevard**	**657**	293
TQ0545	**Boulevard**	**663**	760
TQ0558	**Boulevard**	**701**	148
TQ0596	**Boulevard**	**758**	64
TQ0568	**Boulevard**	**804**	246
TQ0561	**Boulevard**	**1001**	459
TQ0520	**Boulevard**	**1063**	320
TQ0515	**Boulevard**	**1077**	67
TQ0564	**Boulevard**	**1118**	168
TQ0577	**Boulevard**	**1176**	517
TQ0535	**Boulevard**	**1240**	157
TQ0570	**Boulevard**	**1241**	298
TQ0562	**Boulevard**	**1530**	36
TQ0533	**Boulevard**	**1543**	431
TQ0553	**Boulevard**	**1703**	479
TQ0511	**Boulevard**	**1890**	476
TQ0526	**Boulevard**	**1927**	408
TQ0522	**Boulevard**	**2060**	375
TQ0534	**Boulevard**	**2167**	983
TQ0503	**Boulevard**	**2530**	735
TQ0551	**Boulevard**	**2620**	193
TQ0552	**Boulevard**	**2673**	465
TQ0584	**Boulevard**	**2967**	712
TQ0539	**Boulevard**	**3137**	1125
TQ0567	**Boulevard**	**3480**	1457
TQ0509	**Boulevard**	**6297**	2861
TQ0501	**Boulevard**	**6330**	1020
TQ0581	**Cemetery**	**335**	216
TQ0574	**Cemetery**	**593**	88
TQ0606	**Residence**	**884**	204
TQ0601	**Residence**	**1057**	210

Site	Site Type	Zn (ug/g)	S.D.
TQ0603	Park/Playground	55	7
TQ0604	Park/Playground	66	9
TQ0602	Park/Playground	88	33
TQ0541	Park/Playground	92	6
TQ0536	Park/Playground	99	36
TQ0600	Park/Playground	118	111
TQ0580	Park/Playground	128	17
TQ0542	**Park/Playground**	**430**	555
TQ0585	**Park/Playground**	**461**	235
TQ0579	**Park/Playground**	**514**	95
TQ0595	**Park/Playground**	**539**	63
TQ0565	**Park/Playground**	**608**	202
TQ0519	**Park/Playground**	**636**	230
TQ0543	**Park/Playground**	**749**	159
TQ0527	**Park/Playground**	**749**	132
TQ0576	**Park/Playground**	**851**	132
TQ0548	**Park/Playground**	**868**	754
TQ0510	**Park/Playground**	**898**	639
TQ0507	**Park/Playground**	**916**	290
TQ0578	**Park/Playground**	**934**	70
TQ0587	**Park/Playground**	**1035**	507
TQ0588	**Park/Playground**	**1089**	498
TQ0575	**Park/Playground**	**1222**	690
TQ0571	**Park/Playground**	**1412**	623
TQ0550	**Park/Playground**	**1501**	886
TQ0563	**Park/Playground**	**1548**	1005
TQ0586	**Park/Playground**	**1725**	2269
TQ0566	**Park/Playground**	**1800**	686
TQ0592	**Park/Playground**	**1973**	420
TQ0560	**Park/Playground**	**2127**	230
TQ0531	**Park/Playground**	**2153**	1224
TQ0514	**Park/Playground**	**2183**	570
TQ0525	**Park/Playground**	**2370**	1660
TQ0559	**Park/Playground**	**2820**	511
TQ0547	**Park/Playground**	**3650**	3145
TQ0549	**Park/Playground**	**4350**	1293
TQ0506	**Golf Course**	**1307**	86
TQ0521	**Golf Course**	**1390**	211
TQ0523	**Golf Course**	**5107**	1648

Site	Site Type	Zn (ug/g)	S.D.
TQ0597	**Vacant Land**	**249**	93
TQ0524	**Vacant Land**	**373**	28
TQ0529	**Vacant Land**	**985**	87
TQ0532	**Vacant Land**	**1171**	484
TQ0569	**Vacant Land**	**1327**	168
TQ0513	**Vacant Land**	**2170**	318
TQ0502	**Vacant Land**	**2300**	220
TQ0582	**Vacant Land**	**2347**	991
TQ0590	**Vacant Land**	**2643**	2851
TQ0556	**Vacant Land**	**4877**	786
TQ0594	**Vacant Land (undeveloped)**	**756**	131
TQ0572	**Vacant Land (undeveloped)**	**1215**	448
TQ0504	**Vacant Land (undeveloped)**	**2300**	211
TQ0544	**Vacant Land (undeveloped)**	**2597**	344
TQ0516	**Vacant Land (undeveloped)**	**2697**	10001
TQ0505	**Vacant Land (undeveloped)**	**3403**	257
TQ0512	**Vacant Land (undeveloped)**	**3583**	922
TQ0540	**Vacant Land (undeveloped)**	**5350**	16777
TQ0546	**Vacant Land (undeveloped)**	**6173**	1733
TQ0518	**Vacant Land (undeveloped)**	**6213**	2679
TQ0538	**Vacant Land (undeveloped)**	**6407**	2504
TQ0508	**Vacant Land (undeveloped)**	**10143**	5559
TQ0537	**Vacant Land (undeveloped)**	**11550**	2300
TQ0593	School yard	89	5
TQ0555	School yard	136	11
TQ0598	**School yard**	**289**	71
TQ0517	**School yard**	**427**	352
TQ0589	**School yard**	**437**	340
TQ0554	**School yard**	**4087**	1337
TQ0607	**Park/Playground (Bakers Narrows)**	**243**	127
TQ0608	Park/Playground (Cranberry Portage)	39	8

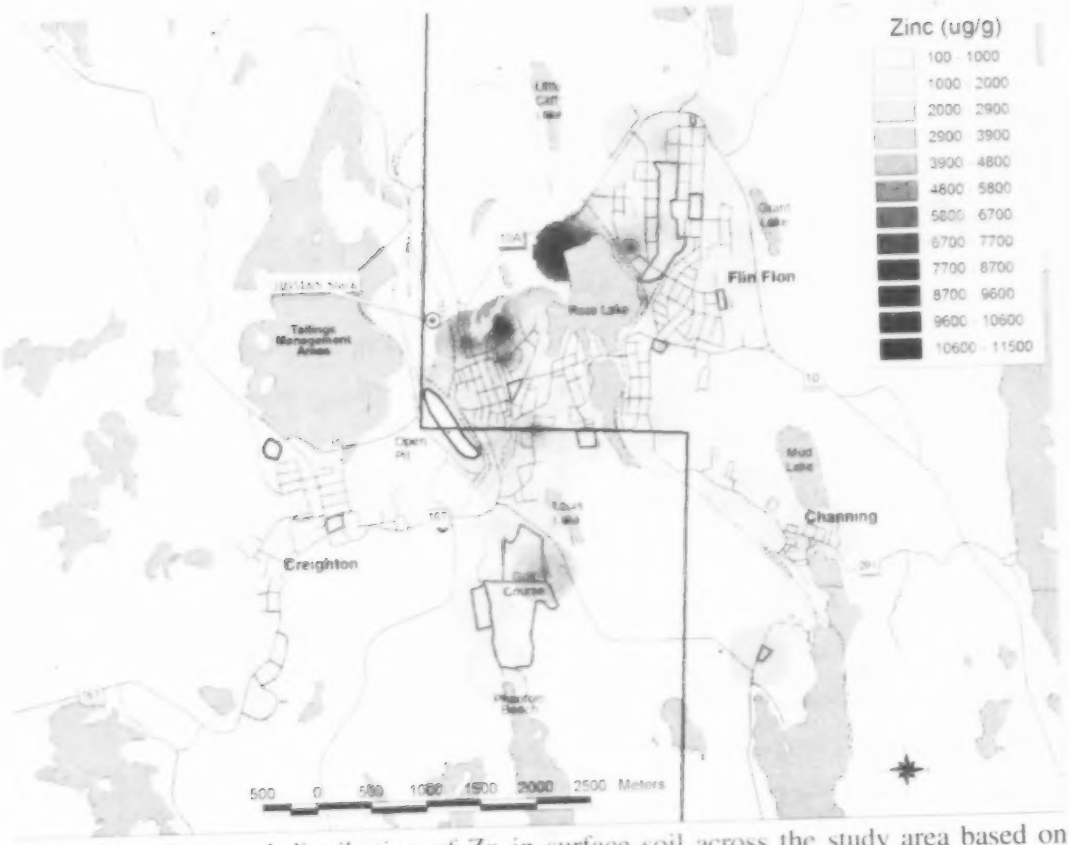


Figure 18. Projected distribution of Zn in surface soil across the study area based on IDW interpolation of the mean Zn concentrations at 106 sample sites.

Antimony (Sb), Molybdenum (Mo), Silver (Ag), and Sulphur (S)

Since CCME soil quality guidelines have not been derived for Sb, Mo, Ag, and S, these elements were assessed by comparing the sampling results to existing interim environmental quality criteria for residential/parkland soil (CCME 1991).

Mean concentrations of Sb were below detection (<0.1 µg/g) at 26 of the 106 sites sampled in Flin Flon and Creighton (Table 12). Concentrations were also below detection at the sites at Bakers Narrows and Cranberry Portage. Detectable concentrations of the metal ranged from 0.1 µg/g to 9.0 µg/g. The highest mean concentrations of Sb were found at sites located on vacant undeveloped lands. A couple of boulevard sites and two of the three sites sampled at the golf

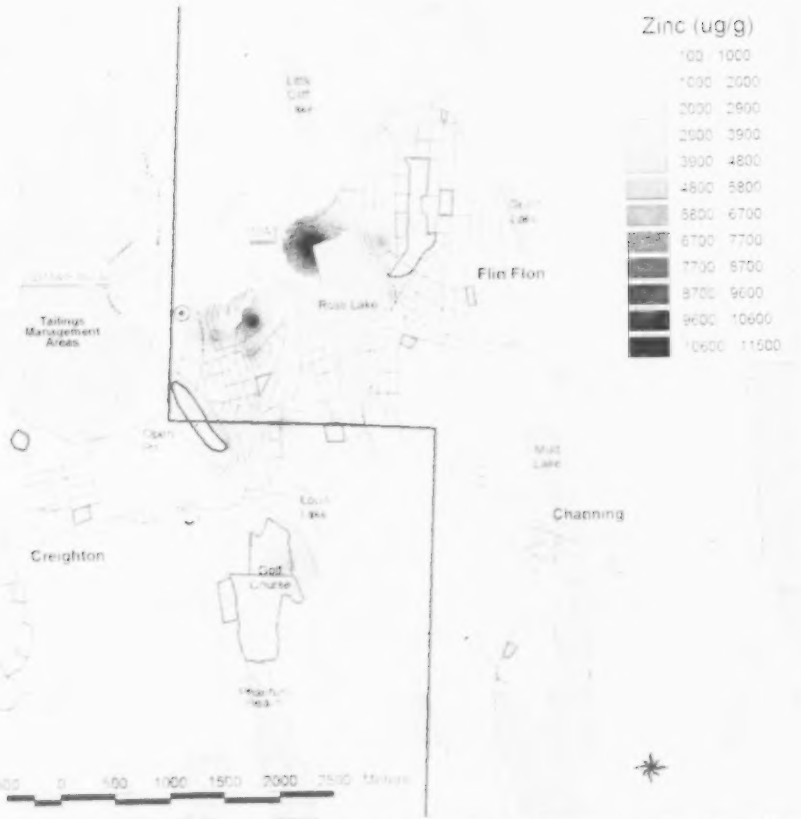


Figure 18. Projected distribution of Zn in surface soil across the study area based on IDW interpolation of the mean Zn concentrations at 106 sample sites.

Antimony (Sb), Molybdenum (Mo), Silver (Ag), and Sulphur (S)

Since CCME soil quality guidelines have not been derived for Sb, Mo, Ag, and S, these elements were assessed by comparing the sampling results to existing interim environmental quality criteria for residential/parkland soil (CCME 1991).

Mean concentrations of Sb were below detection (<0.1 µg/g) at 26 of the 106 sites sampled in Flin Flon and Creighton (Table 12). Concentrations were also below detection at the sites at Bakers Narrows and Cranberry Portage. Detectable concentrations of the metal ranged from 0.1 µg/g to 9.0 µg/g. The highest mean concentrations of Sb were found at sites located on vacant undeveloped lands. A couple of boulevard sites and two of the three sites sampled at the golf

course also had elevated concentrations of Sb relative to the other study sites. The CCME interim environmental quality criterion for Sb in residential parkland soil is 20 µg/g (CCME 1991). This criterion was not exceeded in any of the soil samples collected.

Molybdenum was detected at all of the sites sampled (Table 12). Mean concentrations in Flin Flon and Creighton ranged from 0.3 µg/g to 4.1 µg/g and all were higher than at the site in Cranberry Portage. Overall, the highest concentrations of Mo were usually found in soils on undeveloped parcels of land, vacant lots, boulevards, and parks/playgrounds in the older western half of Flin Flon. All of the sites sampled had mean concentrations of Mo below the CCME interim environmental quality criterion of 10 µg/g for residential/parkland soil (CCME 1991).

Silver concentrations were below detection (<0.1 µg/g) at 11 of the 106 sites sample in Flin Flon and Creighton (Table 12). Most of these sites were located in playgrounds and school yards. The metal was also below detection at the sites in Bakers Narrows and Cranberry Portage. At other sites, concentrations ranged from 0.1 µg/g to 6.5 µg/g, with the highest concentrations found in soil from sites on undeveloped land and boulevards in Flin Flon. All concentrations were well below the CCME interim environmental quality criterion of 20 µg/g for residential/parkland soil (CCME 1991).

Sulphur concentrations were reported by the laboratory as percentage values and then converted to µg/g for presentation in this report. Mean concentrations across the study area ranged from 267 µg/g at a school yard site in Flin Flon to 8333 µg/g at a boulevard site just south of the hospital in Flin Flon (Table 12). Concentrations of S were quite variable across the study area. The highest concentrations were recorded at sites in the older core area of Flin Flon, as well as at several sites located northeast of the smelter in Flin Flon and south of the tailings management area in Creighton (Figure 19). Mean concentrations of S at the Bakers Narrows and Cranberry Portage sites were 500 µg/g and 1067 µg/g, respectively, which is within the lower end of the range recorded for sites in Flin Flon and Creighton.

Table 12. Mean concentrations of Sb, Mo, Ag, and S in surface soil samples collected from sites in Flin Flon and Creighton, August 2006. The ten highest concentrations for each element are in bold font. Creighton sites are enclosed in borders. (n = 3, S.D. = standard deviation).

Site	Site Type	Sb (ug/g)	S.D.	Mo (ug/g)	S.D.	Ag (ug/g)	S.D.	S (ug/g)	S.D.
TQ0501	Boulevard	3.2	1.2	**4.2**	0.6	**5.5**	0.4	**7200**	**2400**
TQ0503	Boulevard	2.0	0.7	2.4	0.5	2.1	0.5	**8333**	**1790**
TQ0509	Boulevard	**4.1**	**1.9**	**3.8**	**0.7**	**2.8**	**0.9**	5633	1419
TQ0511	Boulevard	1.0	0.5	2.4	0.8	1.0	0.4	5833	1124
TQ0515	Boulevard	1.1	0.6	2.3	0.4	0.7	0.1	3667	702
TQ0521	Boulevard	0.9	0.3	2.2	0.7	0.6	0.2	3767	2610
TQ0522	Boulevard	0.9	0.1	2.1	0.9	1.0	0.4	2067	252
TQ0526	Boulevard	1.4	0.2	2.2	0.1	1.0	0.1	**5867**	**1850**
TQ0528	Boulevard	< 0.1		1.7	1.0	0.3	0.2	1300	600
TQ0530	Boulevard	< 0.1		0.8	0.4	0.2	0.1	1133	586
TQ0533	Boulevard	1.0	0.3	1.8	0.6	0.7	0.2	2667	764
TQ0534	Boulevard	1.2	0.6	2.1	0.5	0.8	0.4	5400	819
TQ0535	Boulevard	0.7	0.1	1.3	0.1	0.5	0.1	2500	100
TQ0539	Boulevard	1.8	0.9	2.0	0.2	1.1	0.4	2967	929
TQ0545	Boulevard	0.8	0.0	1.3	0.0	0.4	0.4	667	643
TQ0551	Boulevard	1.2	0.2	1.4	0.3	0.7	0.1	1900	361
TQ0552	Boulevard	1.2	0.2	1.2	0.5	0.7	0.5	2533	321
TQ0553	Boulevard	1.0	0.5	1.4	0.5	0.6	0.1	2567	577
TQ0557	Boulevard	< 0.1		0.8	0.2	0.2	0.0	1633	1710
TQ0558	Boulevard	0.6	0.1	1.0	0.2	0.3	0.1	4267	907
TQ0561	Boulevard	0.8	0.0	1.2	0.4	0.5	0.5	1967	929
TQ0562	Boulevard	1.0	0.1	1.4	0.1	0.6	0.1	2067	208
TQ0564	Boulevard	1.6	1.2	1.3	0.5	0.5	0.1	967	551
TQ0567	Boulevard	1.9	0.6	2.0	0.4	1.5	0.7	**6767**	**2054**
TQ0568	Boulevard	0.7	0.1	1.4	0.1	0.4	0.1	1300	557
TQ0570	Boulevard	1.0	0.5	1.7	0.6	0.5	0.1	1300	458
TQ0573	Boulevard	< 0.1		0.8	0.1	0.1	0.1	833	351
TQ0577	Boulevard	0.9	0.4	1.5	0.6	0.5	0.1	2133	1210
TQ0583	Boulevard	< 0.1		0.5	0.0	0.1	0.0	1167	351
TQ0584	Boulevard	1.2	0.2	0.9	0.2	0.6	0.1	1800	100
TQ0591	Boulevard	0.6	0.0	1.1	0.8	0.3	0.2	733	493
TQ0506	Boulevard	2.2	0.2	1.5	0.2	1.1	0.1	**5900**	**872**
TQ0599	Boulevard	< 0.1		0.8	0.2	0.5	0.3	3100	2066
TQ0605	Boulevard	< 0.1		1.4	0.2	0.3	0.1	3667	473
TQ0574	Cemetery	< 0.1		1.6	0.8	< 0.1		1267	551
TQ0581	Cemetery	< 0.1		0.4	0.3	0.2	0.0	467	115
TQ0501	Residence	1.4	0.4	1.9	0.5	0.8	0.2	3133	1222
TQ0606	Residence	1.9	1.0	1.1	0.6	**2.5**	**1.4**	2967	1474

Site	Site Type	Sb (ug/g)	S.D.	Mo (ug/g)	S.D.	Ag (ug/g)	S.D.	S (ug/g)	S.D.
TQ0507	Park/Playground	0.8	0.4	1.4	0.8	0.5	0.2	2067	764
TQ0510	Park/Playground	1.2	0.4	2.4	2.5	0.6	0.4	1267	1002
TQ0514	Park/Playground	1.7	0.4	**4.0**	**0.6**	1.6	0.4	5700	1253
TQ0519	Park/Playground	0.6	0.0	0.7	0.2	0.3	0.1	1400	800
TQ0525	Park/Playground	1.3	1.1	2.5	1.6	1.1	0.6	1833	1457
TQ0527	Park/Playground	1.1	0.4	1.1	0.6	0.4	0.2	1133	58
TQ0531	Park/Playground	1.3	0.1	1.2	0.5	0.7	0.4	1800	557
TQ0536	Park/Playground	< 0.1		0.8	0.4	< 0.1		667	153
TQ0541	Park/Playground	< 0.1		0.5	0.2	< 0.1		967	635
TQ0542	Park/Playground	< 0.1		0.6	0.6	< 0.1		2967	3707
TQ0543	Park/Playground	0.8	0.1	1.9	0.1	0.6	0.1	3700	1652
TQ0547	Park/Playground	2.2	1.2	1.2	0.3	0.7	0.5	1467	611
TQ0548	Park/Playground	0.7	0.0	0.9	1.0	0.3	0.2	1400	1179
TQ0549	Park/Playground	2.9	2.1	1.5	0.1	1.3	0.5	1200	557
TQ0550	Park/Playground	0.9	0.5	0.6	0.1	0.4	0.2	533	58
TQ0559	Park/Playground	1.5	0.5	1.4	0.5	0.8	0.1	2667	379
TQ0561	Park/Playground	1.0	0.1	1.3	0.2	0.5	0.1	1533	535
TQ0563	Park/Playground	1.4	0.5	2.2	0.5	0.6	0.5	2267	1434
TQ0565	Park/Playground	< 0.1		1.1	0.5	0.3	0.1	1033	666
TQ0566	Park/Playground	1.0	0.5	1.5	0.1	0.6	0.5	1533	1222
TQ0571	Park/Playground	0.8	0.1	1.0	0.5	0.4	0.2	700	100
TQ0575	Park/Playground	< 0.1		0.4	0.1	0.3	0.1	1133	737
TQ0576	Park/Playground	0.6	0.0	1.4	0.1	0.4	0.1	2033	252
TQ0578	Park/Playground	0.7	0.3	2.4	1.0	0.3	0.1	800	265
TQ0579	Park/Playground	0.7	0.1	1.5	0.3	0.3	0.1	4967	802
TQ0580	Park/Playground	< 0.1		0.6	0.5	< 0.1		567	208
TQ0585	Park/Playground	< 0.1		0.9	1.0	0.1	0.1	433	153
TQ0586	Park/Playground	0.5	0.5	2.1	0.6	0.4	0.4	1100	520
TQ0587	Park/Playground	0.9	0.4	**3.3**	**1.1**	0.7	0.2	1400	200
TQ0588	Park/Playground	0.8	0.1	1.6	0.5	0.5	0.3	1467	551
TQ0592	Park/Playground	1.4	0.2	**3.8**	**0.8**	1.3	0.5	4933	1365
TQ0595	Park/Playground	1.5	0.5	2.0	0.3	0.8	0.1	**7267**	**1415**
TQ0601	Park/Playground	< 0.1		0.5	0.5	< 0.1		400	200
TQ0602	Park/Playground	< 0.1		0.3	0.1	< 0.1		333	153
TQ0603	Park/Playground	< 0.1		0.4	0.1	< 0.1		467	153
TQ0604	Park/Playground	< 0.1		0.3	0.1	< 0.1		367	208
TQ0508	Golf Course	**3.7**	**0.4**	1.6	0.4	1.5	0.2	2100	361
TQ0521	Golf Course	1.4	0.5	2.0	0.6	0.9	0.2	4333	1570
TQ0523	Golf Course	**3.9**	**1.1**	2.5	0.3	1.8	0.6	3867	808

Site	Site Type	Sb (ug/g)	S.D.	Mo (ug/g)	S.D.	Ag (ug/g)	S.D.	S (ug/g)	S.D.
TQ0502	Vacant Land	1.5	0.2	2.6	0.2	1.2	0.1	**7867**	**1422**
TQ0513	Vacant Land	2.8	0.2	2.5	0.5	1.5	0.2	4567	802
TQ0524	Vacant Land	< 0.1		1.1	0.3	0.2	0.1	1000	361
TQ0529	Vacant Land	< 0.1		1.6	0.2	0.4	0.1	1367	404
TQ0532	Vacant Land	0.6	0.1	1.3	0.4	0.5	0.1	1567	1589
TQ0556	Vacant Land	2.0	0.3	0.9	0.2	1.0	0.2	1367	802
TQ0569	Vacant Land	1.0	0.4	2.2	0.8	0.6	0.1	2133	586
TQ0582	Vacant Land	1.6	1.0	0.8	0.1	0.7	0.3	700	100
TQ0590	Vacant Land	3.2	1.7	0.7	0.3	0.4	0.5	733	586
TQ0597	Vacant Land	1.0	0.5	**3.6**	**0.6**	0.5	0.2	3767	2830
TQ0504	Vacant Land (undeveloped)	1.7	0.5	3.2	1.1	1.9	0.6	**6367**	**586**
TQ0505	Vacant Land (undeveloped)	**9.0**	**2.0**	**4.1**	**0.6**	**6.5**	**1.4**	4200	1908
TQ0508	Vacant Land (undeveloped)	**6.7**	**1.5**	**5.1**	**1.0**	**6.0**	**1.2**	3900	200
TQ0512	Vacant Land (undeveloped)	1.7	0.5	1.5	0.7	1.2	0.2	**7633**	**3293**
TQ0516	Vacant Land (undeveloped)	1.4	1.1	2.1	0.8	1.2	0.6	2933	513
TQ0518	Vacant Land (undeveloped)	**5.0**	**0.7**	**3.3**	**1.0**	**2.8**	**0.4**	2533	3960
TQ0537	Vacant Land (undeveloped)	**6.4**	**1.3**	**4.9**	**2.7**	**4.5**	**1.2**	**6967**	**1007**
TQ0538	Vacant Land (undeveloped)	**6.3**	**2.6**	**1.8**	0.2	**3.4**	**1.3**	2267	1415
TQ0540	Vacant Land (undeveloped)	2.5	0.6	1.8	1.0	1.6	0.5	3333	1557
TQ0544	Vacant Land (undeveloped)	**4.2**	**0.7**	1.8	0.2	**2.3**	**0.5**	1300	1300
TQ0546	Vacant Land (undeveloped)	**4.2**	**1.8**	2.2	1.0	**2.5**	**1.0**	667	58
TQ0572	Vacant Land (undeveloped)	0.9	0.6	1.9	0.9	0.5	0.3	600	173
TQ0594	Vacant Land (undeveloped)	2.7	1.0	1.6	0.2	1.3	0.6	2200	200
TQ0517	School yard	< 0.1		0.7	0.5	0.3	0.2	1400	1905
TQ0554	School yard	1.4	0.6	0.6	0.4	0.7	0.4	1467	833
TQ0555	School yard	< 0.1		0.3	0.2	< 0.1		267	115
TQ0589	School yard	< 0.1		1.6	0.5	0.3	0.1	1167	1159
TQ0593	School yard	< 0.1		0.3	0.1	< 0.1		333	115
TQ0598	School yard	0.7	0.0	1.2	0.4	0.4	0.2	1733	1012
TQ0607	Park/Playground (Bakers Narrows)	< 0.1		0.6	0.1	< 0.1		1067	306
TQ0608	Park/Playground (Cranberry Portage)	< 0.1		0.2	0.1	< 0.1		500	173

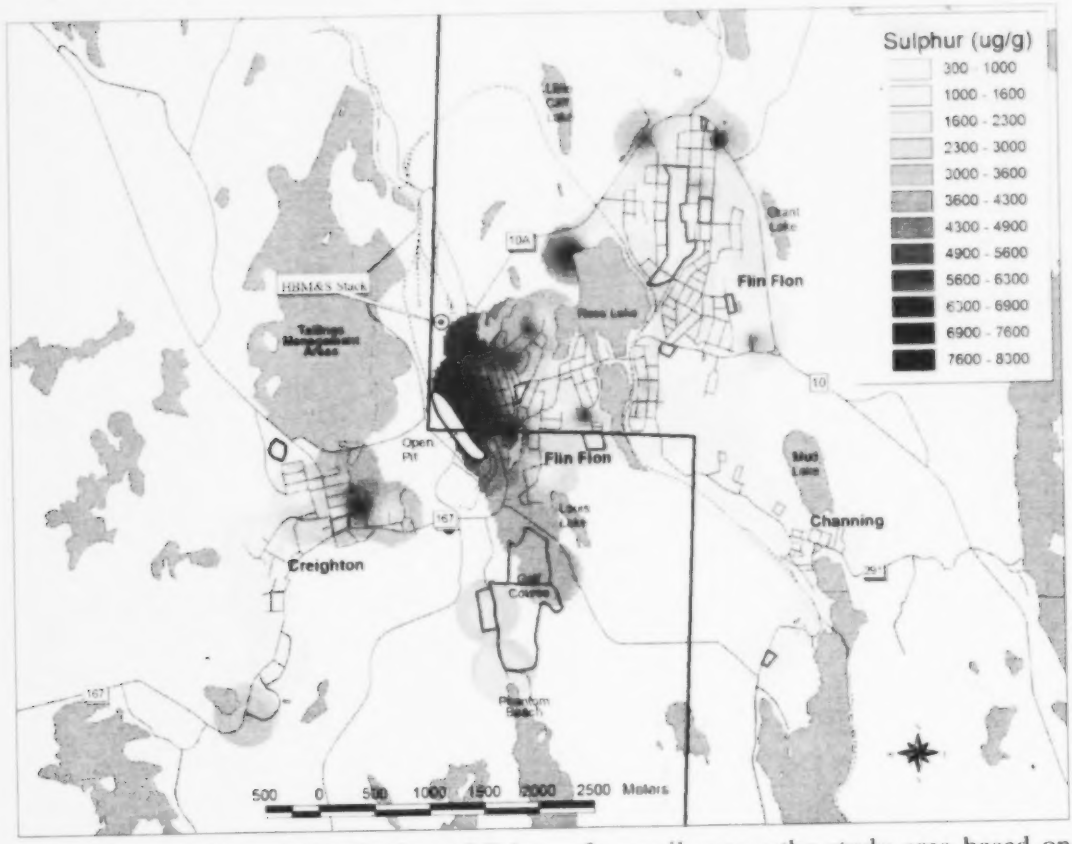


Figure 19. Projected distribution of S in surface soil across the study area based on IDW interpolation of the mean S concentrations at 106 sample sites.

Sulphur is an essential nutrient and is required in small amounts by most plants and animals (Brady 1974). Sulphur in the soil only becomes a health concern for humans at very high concentrations. Exposure to S through inhalation of gaseous forms of the element (e.g. SO_2) presents a much greater risk to human health than exposure to S in the soil. Consequently, human health related guidelines and criteria for the element in soil have not been developed.

Sulphur deficiency can be a problem in some agricultural soils and producers often need to add fertilizers in order to supplement the amount of S available for plant growth (Brady 1974). Adding sulphur to soil has to be done with care as too much S in the soil can lead to an increase in soil acidity, which may result in a decrease in plant available phosphorous and an increase in the availability of heavy metals (Brady 1974). The CCME has recommended an interim environmental quality criterion of 500 µg/g for S in agricultural soils (CCME 1991). This criterion was exceeded at most of the sites sampled, including the sites in Cranberry Portage and

Bakers Narrows. Thus, while S concentrations are elevated across most of Flin Flon and Creighton, any concern is for vegetation establishment and growth, and not human health.

Other Elements

CCME guidelines also exist for barium (Ba), Cr, Ni, and vanadium (V) (CCME 1999), while CCME interim environmental quality criteria exist for Co (CCME 1991, 1999). Results for these elements can be found in the Appendix section of this report.

The guideline for Cr derived specifically for the protection of human health in residential/parkland soil is 220 µg/g (CCME 1999). Although levels of Cr were fairly wide ranging across the study area (from 13.7 µg/g to 171.7 µg/g in Flin Flon, and from 14.3 µg/g to 192.3 µg/g in Creighton), the highest concentrations were still below the CCME guideline. The CCME guideline for Ni is 50 µg/g (CCME 1999). This guideline was developed to ensure protection of the environment and is based on the negative effects of Ni on microbial activity in the soil. At present there is no human health guideline for Ni in soil. The environmental guideline of 50 µg/g was exceeded by a relatively small margin at a single site in Creighton and at four sites in Flin Flon. Concentrations of Cr and Ni were highly correlated with each other (Spearman's coefficient = 0.93), but generally not with the other elements tested. This suggests that levels in the soil may reflect natural variation across the study area, and that some of the higher concentrations may be due to localized contamination from a source or sources other than the smelter complex.

Although human health protection guidelines have not been determined for Ba and V, CCME has published environmental protection guidelines for both elements. The guideline for environmental protection for Ba in residential/parkland soil is 500 µg/g, while the guideline for V is 130 µg/g (CCME 1999). The highest mean concentration of Ba recorded in the study area was 194 µg/g, while that for V was 83 µg/g. Thus, concentrations of both elements were well below existing environmental guidelines and should pose no concern from a human health perspective. The interim environmental quality criterion for Co in soil intended for residential/ parkland use is 50 µg/g (CCME 1991). Mean concentrations of Co ranged from 2 µg/g to 22 µg/g across the study area, well below the interim environmental quality criterion at all of the sites sampled.

Conclusions

The primary objective of this survey was to determine the concentrations of metals and other elements in surface soil in the communities of Flin Flon and Creighton. This was accomplished by collecting and analyzing surface soil samples from a total of 108 sampling sites, including 93 sites in Flin Flon, 13 sites in Creighton, a site at Bakers Narrows Provincial Park, and a site in Cranberry Portage. The laboratory analysis results showed that surface soil concentrations of Sb, As, Cd, Cu, Pb, Hg, Mo, Se, Ag, S, Tl, and Zn were elevated across much of Flin Flon and Creighton relative to the concentrations at the sample site in Cranberry Portage. Concentrations of these elements in soil were also very highly positively inter-correlated, suggesting that they originated from a common source. As well, based on historical data and on-going environmental monitoring programs, these elements are known or suspected constituents of past and present atmospheric emissions from the smelter complex. This information indicates that the smelter complex is an important source of these elements in the surface soil of Flin Flon and Creighton. It must be stressed that the concentrations of these elements have accumulated in the soil over time and they do not necessarily reflect atmospheric deposition at present or even in the recent past.

The second objective of this survey was to describe the distribution of metals and other elements in the surface soils. The data revealed that the highest concentrations of Sb, As, Cd, Cu, Pb, Hg, Mo, Se, Ag, S, Tl, and Zn were usually found at sites located on undeveloped parcels of land. This is not unexpected since soils at these sites have probably been exposed to atmospheric deposition for a longer period of time than soils in areas that have undergone some form of alteration from development and landscaping. Several boulevard, vacant lot, and park/playground sites in Flin Flon also had consistently high concentrations of these elements. These sites tend to be located in older neighbourhoods and were closer to the smelter. Soils in these areas have been exposed to atmospheric emissions for a long period of time compared to more recently developed areas of Flin Flon. Also, prior to 1974, atmospheric emissions were discharged through a series of relatively short stacks, which likely resulted in more localized deposition of metals and other elements in areas nearer to the smelter.

A computer program was used to interpolate the data and map the potential distribution of Sb, As, Cd, Cu, Pb, Hg, Mo, Se, Ag, S, Tl, and Zn across the study area based on the mean concentration data recorded at the study sites. The results indicate that concentrations of the elements may be highest throughout the downtown core and adjacent residential areas of Flin Flon south of the smelter, as well as in undeveloped areas around the north basin of Ross Lake. Caution is advised in interpreting the interpolation and mapping results since they are only estimates of concentrations between sites based only on the data for each site. The interpolation method used may have actually over estimated the spatial extent of soils with high concentrations. Such soils may in fact be much more localized and confined to undeveloped areas. It is entirely possible that, because of landscaping and other alterations, concentrations of these elements in residential lots, parks/playgrounds, and boulevards in the immediate vicinity of undeveloped lands are considerably lower than what was calculated by the interpolation method.

The final objective of this survey was to provide a preliminary assessment of the soil quality by comparing the results to existing CCME guidelines. The CCME residential/parkland guidelines derived for the protection of human health were used because the survey was conducted primarily in residential areas within an urban setting and all of the sample sites were readily accessible to the public. A few of the sample sites in the downtown area of Flin Flon may have been influenced by activities in adjacent commercial and industrial lots. However, because these sites were not located specifically on commercial or industrial lands they were still assessed using residential/parkland guidelines.

Concentrations of As, Cd, Cu, Pb, and Hg exceeded soil quality guidelines for the protection of human health at a fairly high proportion of the sites sampled (Table 13), while concentrations of Se and Tl exceeded their respective guideline at fewer sites. There is no CCME human health protection guideline for Zn in soil because it is only toxic to humans at very high concentrations. There is, however, a guideline derived to protect environmental health and this was exceeded at all but a few of the sites sampled. CCME interim environmental quality criteria were used to assess the concentrations of Sb, Mo, Ag, and S because CCME soil quality guidelines for these elements have not been established. Although concentrations of these elements were elevated across much of Flin Flon and Creighton relative to the sites at Bakers Narrows and Cranberry Portage, none of the existing interim environmental quality criteria for residential/parkland soils were exceeded.

Table 13. Number and percentage of sites where concentrations of selected elements exceeded CCME residential/parkland guidelines for human health protection in the Flin Flon and Creighton study area, August 2006.

		Arsenic		Cadmium		Copper		Lead		Mercury		Selenium		Thallium		Zinc	
	Guideline	12 ug/g		14 ug/g		1100 ug/g		140 ug/g		6.6 ug/g		28 ug/g		1 ug/g		200 ug/g*	
Site Type	No. of Sites Sampled	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Park/Playground	36	17	47	8	22	4	11	5	14	14	39	0	0	0	0	30	83
Boulevard	34	23	68	7	21	9	26	14	41	17	50	3	9	1	3	33	97
Vacant Land (undeveloped)	13	13	100	10	77	11	85	12	92	11	85	2	15	1	8	13	100
Vacant Land	10	9	90	4	40	2	20	5	50	5	50	0	0	0	0	10	100
School yard	6	2	33	0	0	0	0	1	17	2	33	0	0	0	0	4	67
Golf Course	3	3	100	2	67	1	33	3	100	3	100	0	0	0	0	3	100
Cemetery	2	1	50	1	50	1	50	1	50	1	50	0	0	0	0	2	100
Residence	2	2	100	1	50	0	0	2	100	1	50	0	0	0	0	2	100
Total	**106**	**70**	**66**	**33**	**31**	**28**	**26**	**43**	**41**	**54**	**51**	**5**	**5**	**2**	**2**	**97**	**92**

* environmental health guideline

(Note this summary does not include results from sites in Cranberry Portage and Bakers Narrows).

This is based on the assessment of the results using CCME guidelines for human health protection. It must be emphasized, however, that the CCME guidelines for human health protection are very conservative and are derived based on a scenario of prolonged, year-round exposure of the most vulnerable individuals. For soil guidelines the most vulnerable individuals are children since they are more liable to have direct exposure to soil through dermal contact and ingestion (pica) during play. The climate of Flin Flon and Creighton may alleviate some of the exposure risk since the soils in the region are usually covered with snow for five to six months of the year. Also, most children play in parks/playgrounds, school yards, and on lawns in residential yards. Although guidelines were exceeded at some of the park/playground and school yard sites sampled, in general the soils associated with these land uses tended to have less elevated concentrations of these elements. Private residential yards were not sampled to any extent in this survey. However, since landscaping and maintenance practices are similar, private lawns and yards may have element concentrations comparable to parks/playgrounds, school yards and perhaps boulevards in the general vicinity.

CCME guidelines provide a preliminary indication of concentrations of elements and other substances in soil that may require further evaluation from a health perspective. A more detailed

assessment should be undertaken to examine if there is any health risk when all exposure pathways are considered.

In conclusion, this survey has achieved its original objectives, which include:

- determination of the concentrations of metals and other elements in surface soil in the communities of Flin Flon and Creighton;
- description of the distribution of metals and other elements in the surface soils; and
- provision of a preliminary assessment of the soil quality by comparing the results to existing CCME guidelines.

References

ATSDR (Agency for Toxic Substances and Disease Registry). 1992. *Toxicological Profile for Thallium.* U.S. Department of Health and Human Services, Public Health Service. Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp54.html

ATSDR. 2005. *Toxicological Profile for Zinc.* U.S. Department of Health and Human Services, Public Health Service. Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp60.html#bookmark03

Brady, N. C. 1974. *The Nature and Properties of Soil (8th Ed.).* McMillan Publishing Co., Inc., New York, NY. 639 pp.

Cantox Environmental Inc, MGI Ltd., Genivar, GlobalTox International Consultants Inc. 2006. *The Study of Soils in the West Wharf Area, Dalhousie, New Brunswick. Final Report.* Prepared for Noranda Inc., Bathurst , NB. (note: MGI Ltd. is now Conestoga-Rovers and Associates). .Available at http://www.ewws.ca/media_uploads/pdf/83.pdf

CCME (Canadian Council of Ministers of the Environment). 1991. *Interim Canadian Environmental Quality Criteria for Contaminated Sites.* CCME, Winnipeg, MB.

CCME. 1999 (plus updates to Nov, 2006). *Canadian Environmental Quality Guidelines.* CCME, Winnipeg, MB.

ESRI (Environmental System Research Institute). 2000. *ArcView Spatial Analyst 2.* Environmental System Research Institute. Redlands, CA.

ESRI (Environmental System Research Institute). 2002. *ArcView GIS 3.3.* Environmental System Research Institute. Redlands, CA.

HBM&S Environment. 1994. *Heavy Metals in Flin Flon Area Gardens.* Final report. Unpublished material. Hudson Bay Mining & Smelting, Flin Flon, MB. 10 pp.

Henderson, P. J., I. McMartin, G. E. Hall, J. B. Percival, and D. A. Walker. 1998. The chemical and physical characteristics of heavy metals in the humus and till in the vicinity of the base metal smelter at Flin Flon, Manitoba, Canada. Environmental Geology 34:39-58.

Hogan, G. D. and D. L. Wotton. 1980. *A Preliminary Report on the Effects of Atmospheric Effluents from Mining and Smelting Industries on Forest Vegetation and Soils.* Submission to the Clean Environment Commission, Province of Manitoba. Winnipeg, MB. 104 pp.

Hogan, G. D. and D. L. Wotton. 1984. Pollutant Distribution and Effects in Forests Adjacent to Smelters. Journal of Environmental Quality 13:377-382.

Jones, D. 1983. *A Status Report on the Lead Concentration in Sod and Soil for Flin Flon – Channing, Manitoba, 1982*. Terrestrial Standards and Studies Section, Manitoba Environment. Winnipeg , MB. Terrestrial Standards and Studies Report #83-1. 9 pp.

Jones, G. and F. Phillips. 2003. *Metal Concentrations in Surface Soils of Thompson, Manitoba, September 2001*. Habitat Management and Ecosystem Monitoring Section, Wildlife and Ecosystem Protection Branch, Manitoba Conservation. Winnipeg, MB. Manitoba Conservation Report No. 03-01. 21 pp. Available at http://www.gov.mb.ca/conservation/wildlife/managing/pdf/thompson_metalcon.pdf

Jones, G. and V. Henderson. 2006. *Metal Concentrations in Soil and Produce from Gardens in Flin Flon, Manitoba, 2002*. Habitat Management and Ecosystem Monitoring Section, Wildlife and Ecosystem Protection Branch, Manitoba Conservation. Winnipeg, MB. Manitoba Conservation Report No. 2006-01. 81 pp. Available at http://www.gov.mb.ca/conservation/wildlife/managing/pdf/flinflon_metalcon.pdf

MAC. 2006. *Towards Sustainable Mining Progress Report, 2005: Total Releases by Company and Substance*. The Mining Association of Canada. Ottawa, ON. Available at: http://www.mining.ca/www/media_lib/TSM_Publications/TSM_Progress_Report_2006/TSM_05_Release_tables_ENG.pdf.

McMartin I., P. J. Henderson, and E. Nielson. 1999. Impact of a base metal smelter on the geochemistry of soils of the Flin Flon region, Manitoba and Saskatchewan. Canadian Journal of Earth Science 36:141-160.

McEachern, D. B. and S. F. Phillips. 1983. *Monitoring for Mercury and Lead in Blueberry Plants (Vaccinium myrtilloides Michx.) of the Flin Flon Area, 1980 and 1981*. Terrestrial Standards and Studies Section, Environmental Management Services Branch, Department of Environment and Workplace Safety and Health. Report #83-12. Winnipeg, MB. 25 pp.

Phillips, S. F., D. L. Wotton, D. B. McEarchern, and D. C. Jones. 1983. *Snow Chemistry in the Flin Flon area of Manitoba, 1981-1983*. Terrestrial Standards and Studies, Environmental Management Division, Manitoba Department of Environment and Workplace Safety and Health. Report #83-13. Winnipeg, MB. 36 pp.

Phillips, S. F., D. L. Wotton, and D. B. McEarchern. 1986. Snow Chemistry in the Flin Flon area of Manitoba, 1981-1984. Water, Air, and Soil Pollution 30:253-261.

Pip, E. 1991. Cadmium, copper, and lead in soils and garden produce near a metal smelter at Flin Flon, Manitoba. Bulletin of Environmental Contamination and Toxicology 46:790-796.

Smith, D. B, W. F Cannon, L. G Woodruff, R. G Garrett, R Klassen, J. E. Kilburn, J. D. Horton, H. D. King, M. B. Goldhaber, and J. M. Morrison. 2005. *Major Trace Element Concentrations in Soils from Two Continental-Scale Transects of the United States and Canada*. United States Geological Survey (USGS) Report OFR2005-1253. USGS, Reston, VA. Available at: http://pubs.usgs.gov/of/2005/1253/

Winterhalder, K. 2003. Minimal amelioration as appropriate technology in the Green Flin Flon/Creighton Project. A paper presented at Sudbury 2003 Mining and the Environment. Laurentian University. Sudbury, ON.

WHO (World Health Organization). 1998. *Environmental Health Criteria 200: Copper.* International Programme on Chemical Safety, World Health Organization, Geneva, Switzerland. Available at http://www.inchem.org/documents/ehc/ehc/ehc200.

WHO (World Health Organization). 2000. *WHO Food Additive Series 44: Lead.* International Programme on Chemical Safety, World Health Organization, Geneva, Switzerland. Available at http://www.inchem.org/documents/jecfa/jecmono/v44jec12.

Wood, M. 2001. Investigating minor nutrients of major importance. Agricultural Research Magazine.49:8-10. Available at http://www.ars.usda.gov/is/AR/archive/mar01/.

Wotton, D. L. 1979. *A Survey of Mercury and Lead in Vaccinium myrtiloides Michx. of the Flin Flon area.* Environmental Research and Development Branch, Manitoba Department of Mines, Natural Resources and Environment. Report 79-3. 17pp.

Wotton, D. L., D. B. McEachern, and D. C. Jones. 1983. *A Study of Forest Vegetation in the Flin Flon Area for Atmospheric Emission Effects from the H.B.M.&S. Smelter.* Report 83-11. Terrestrial Standards and Studies Section, Manitoba Department of Environment and Workplace Safety and Health. Report #83-11. Winnipeg, MB,. 51 pp.

Appendix

Table A1. Overall summary statistics for 93 sites sampled in Flin Flon, August 2006. The statistics were derived from the mean concentration data of three replicate samples from each site. Also included for comparison purposes are mean values for three replicate samples collected at Bakers Narrows (site TQ0607) and Cranberry Portage (site TQ0608). Concentrations are in µg/g unless indicated otherwise.

				Percentiles									Bakers	Cranberry
Variable	Min	Max	Mean	10th	20th	30th	40th	50th	60th	70th	80th	90th	Narrows	Portage
Moisture %	0.7	66.4	29.3	8.0	12.9	19.6	22.9	28.8	33.5	39.5	43.0	50.6	28.2	20.0
Density g/cm3	0.3	1.6	0.8	0.4	0.5	0.5	0.6	0.7	0.9	0.9	1.1	1.2	0.68	1.07
pH units	4.0	7.8	6.3	5.3	5.7	6.0	6.1	6.3	6.5	6.6	6.9	7.1	7.1	7.5
Al	2647	34267	8928	4272	5389	5745	6529	7407	8415	10214	12780	15067	8860	12143
Sb	<0.1	9.0	1.4	<0.1	<0.1	0.7	0.9	1.0	1.2	1.4	1.9	3.6	< 0.1	< 0.1
As	2.5	407	36.0	7.5	9.3	11.0	13.4	15.9	21.8	27.5	43.7	83.2	[illegible]	2.5
Ba	21.0	194	77.0	37.1	52.4	57.2	66.6	72.3	79.1	86.1	94.9	119	103	59
B	<1	42	8	3	4	5	6	7	8	10	12	15	7	9
Cd	0.7	70.9	13.6	3.5	5.3	7.6	10.0	11.6	12.4	14.3	16.6	25.9	1.4	< 0.2
Ca	995	23533	7700	1846	2583	4291	5592	6857	8439	9745	11562	14289	18293	9517
Cr	13.7	172	51.6	26.1	32.4	35.6	39.3	44.0	51.5	60.1	70.1	78.5	26	42
Co	2.0	21.7	8.2	4.0	5.1	6.0	6.7	7.7	8.3	9.1	10.4	13.7	7	7
Cu	54	5103	1036	237	349	504	613	728	876	1052	1520	2061	90	26
Fe	4137	73733	15873	8853	9889	11219	12113	14200	15800	16889	19163	23340	13567	15647
Pb	5	1447	196	33	53	85	106	123	147	195	251	437	22	5
Mg	1096	17867	5637	2617	3367	3714	4275	5013	5933	6512	8111	9429	9293	10480
Mn	44	622	232	96	134	161	181	209	231	267	286	427	286	194
Hg	0.1	653	33.0	1.2	2.7	4.3	5.6	7.9	10.5	17.4	27.2	60.0	0.27	0.14
Mo	0.3	5.1	1.7	0.6	0.9	1.2	1.4	1.5	1.7	2.0	2.3	3.1	0.6	0.2
Ni	8	72	27	15	18	19	21	24	28	30	35	38	20	24
P	191	4473	968	357	483	591	751	902	1004	1137	1311	1485	891	808
K	627	8563	2207	1019	1196	1465	1677	1910	2085	2454	2978	3673	1813	2009
Se	<0.2	177	10.2	1.0	1.9	2.6	3.2	3.9	4.4	6.4	10.6	15.8	0.7	0.2
Ag	< 0.1	6.5	0.9	0.1	0.3	0.4	0.5	0.6	0.7	0.9	1.3	2.1	< 0.1	< 0.1
Na	34	1053	149	58	68	80	96	117	128	166	180	256	104	158
Sr	2.3	105	20.1	6.7	8.8	12	14	19	21	24	28	32	25	10
S %	0.027	0.833	0.245	0.067	0.101	0.127	0.140	0.180	0.211	0.267	0.385	0.559	0.107	0.050
Tl	< 0.1	1.2	0.2	< 0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.5	0.1	0.1
Ti	35	1503	400	163	213	248	282	341	379	440	593	694	175	455
V	7.3	81	27	15	18	19	21	24	26	29	35	42	24	38
Zn	39	11550	2052	384	617	886	1112	1390	1897	2300	2771	4771	243	39

Table A2. Overall summary statistics for 13 sites sampled in Creighton, August 2006. The statistics were derived from the mean concentration data of three replicate samples from each site. Also included for comparison purposes are mean values for three replicate samples collected at Bakers Narrows (site TQ0607) and Cranberry Portage (site TQ0608). Concentrations are in µg/g unless indicated otherwise.

				Percentiles									Bakers	Cranberry
Variable	Min	Max	Mean	10th	20th	30th	40th	50th	60th	70th	80th	90th	Narrows	Portage
Moisture %	4.6	62.2	24.9	7.1	7.7	9.4	10.3	12.7	27.9	33.2	42.8	56.5	28.2	20.0
Density g/cm3	0.3	1.7	1.0	0.3	0.5	0.6	0.8	1.1	1.3	1.4	1.5	1.5	0.68	1.07
pH units	4.7	6.5	5.9	5.2	5.4	5.6	5.9	6.1	6.1	6.2	6.3	6.4	7.1	7.5
Al	2883	9963	4813	3253	3303	3371	3484	3553	4922	5535	6203	6862	8860	12143
Sb	< 0.1	2.7	0.9	< 0.1	< 0.1	< 0.1	< 0.1	0.7	1.0	1.5	1.8	2.1	< 0.1	< 0.1
As	2.3	116	43.6	4.2	6.6	10.8	20.0	28.2	51.0	59.8	77.7	107	6.1	2.5
Ba	22.7	120	44.6	24.9	27.3	28.1	33.2	38.0	42.8	48.9	51.9	62.5	103	59
B	1	11	4	1	2	2	3	3	3	4	6	7	7	9
Cd	0.9	20.8	7.3	2.2	2.5	3.0	4.1	8.0	8.3	9.5	11.0	12.0	1.4	< 0.2
Ca	1022	24733	7283	1099	1363	2073	2917	6003	6229	8389	12197	16067	18293	9517
Cr	14	192	41	18	23	26	28	29	31	34	38	39	26	42
Co	2	11	6	2	3	3	4	6	6	7	8	11	7	7
Cu	55	899	403	97	124	230	387	413	433	530	599	701	90	26
Fe	5400	20933	11104	5551	5870	6176	7469	10197	10915	13893	17273	19113	13567	15647
Pb	6	250	92	18	21	43	70	76	86	130	155	172	22	5
Mg	1697	18343	4405	1737	1908	2244	2532	2777	3493	3851	5039	6753	9293	10480
Mn	49	419	155	54	55	90	118	150	157	178	216	246	286	194
Hg	0.1	14.6	3.7	0.1	0.6	1.4	1.9	2.0	3.1	5.0	6.4	6.8	0.27	0.14
Mo	0.3	3.6	1.3	0.3	0.4	0.7	1.1	1.2	1.4	1.6	1.8	1.9	0.6	0.2
Ni	7	82	18	8	11	12	13	13	15	16	17	18	20	24
P	353	2047	899	357	374	397	444	485	1090	1265	1431	1689	891	808
K	804	1997	1200	895	925	993	1051	1108	1118	1152	1351	1867	1813	2009
Se	<0.2	7.2	2.9	0.2	0.5	1.2	1.9	2.5	3.0	4.5	5.2	5.9	0.7	0.2
Ag	<0.1	2.5	0.6	<0.1	<0.1	0.2	0.4	0.5	0.6	0.8	0.9	1.3	< 0.1	< 0.1
Na	39	124	68	42	44	47	52	58	62	80	92	112	104	158
Sr	2	31	10	3	3	4	5	6	9	10	16	25	25	10
S %	0.033	0.727	0.272	0.037	0.043	0.123	0.211	0.297	0.311	0.335	0.373	0.547	0.107	0.050
Tl	<0.1	0.3	0.2	<0.1	<0.1	<0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.1	0.1
Ti	123	379	235	160	164	192	210	216	233	259	317	335	175	455
V	10	29	17	13	13	14	14	14	16	20	23	25	24	38
Zn	55	1057	450	70	100	197	281	340	563	697	757	859	243	39

Table A3. Raw data results for samples collected at sites in Flin Flon, Creighton, Bakers Narrows Provincial Park, and Cranberry Portage. August 2006. (Concentrations are in µg/g unless indicated otherwise. Texture classes: O = organic, S = sand, Si = silt, Cl = clay, Gr = gravel).

Site	Land Use	Vegetation	Rep #	Texture	Moisture (%)	Density (g/cm3)	pH	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe
Flin Flon Sites																			
TQ0501	Boulevard	native grasses/shrubs (dead)	1	S/Si	13.5	0.93	6.2	20900	4.5	238	141	< 1	9	48	5440	80	23	5540	40600
TQ0501	Boulevard	native grasses/shrubs (dead)	2	S/Si	13.1	1.20	6.4	20200	2.5	203	133	< 1	7	36.6	4610	80	20	5390	37200
TQ0501	Boulevard	native grasses/shrubs (dead)	3	S/Si	18.5	1.35	5.7	17200	2.5	166	159	< 1	7	33.3	3880	62	17	3900	33200
TQ0502	Vacant Land	sod grasses	1	O	39.4	0.52	5.3	7900	1.3	52	58	< 1	4	17	5260	32	10	2070	17200
TQ0502	Vacant Land	sod grasses	2	O	39.6	0.45	5.2	7400	1.5	41.6	60	< 1	5	19.7	6420	27	9	2110	13500
TQ0502	Vacant Land	sod grasses	3	O	30.6	0.59	5.2	7480	1.1	47.7	54	< 1	4	12.8	4960	28	9	1730	16500
TQ0503	Boulevard	sod grasses	1	O/Si	21.4	0.78	5.7	7280	1.3	57.9	52	< 1	4	17.7	3690	38	10	1970	18000
TQ0503	Boulevard	sod grasses	2	O/Si	16.3	0.58	5.8	7710	2.6	97.8	65	< 1	5	26.6	5570	38	14	3210	24000
TQ0503	Boulevard	sod grasses	3	O/Si	23.8	0.48	5.9	8050	2.2	96	62	< 1	5	24	6460	38	14	2400	23200
TQ0504	Vacant Land (undeveloped)	native grasses/apsen	1	S	11.6	0.69	6.7	10400	1.2	44.6	57	< 1	11	11.1	5150	100	12	1750	22500
TQ0504	Vacant Land (undeveloped)	native grasses/apsen	2	S	6.1	0.90	6.4	13200	1.6	87.2	71	< 1	7	14.2	3280	58	16	2500	29700
TQ0504	Vacant Land (undeveloped)	native grasses/apsen	3	S/Gr	6.2	1.14	5	10100	2.2	109	58	< 1	6	12.2	1740	66	13	2280	28700
TQ0505	Vacant Land (undeveloped)	none (rock and sand)	1	O/S	14.6	0.86	4.3	15900	11.2	454	171	< 1	4	15.4	1040	32	17	2460	69400
TQ0505	Vacant Land (undeveloped)	none (rock and sand)	2	O/S	11.4	0.78	3.8	13100	8.2	350	217	< 1	5	20.6	1170	29	17	2020	74200
TQ0505	Vacant Land (undeveloped)	none (rock and sand)	3	O/S	12.3	0.76	3.8	18300	7.5	417	193	< 1	7	13.9	827	38	18	1550	77600
TQ0506	Golf Course	sod grasses	1	O/Cl	59.6	0.54	4.5	6040	3.4	143	52	< 1	3	11.1	1240	36	4	857	21900
TQ0506	Golf Course	sod grasses	2	O/Cl	65.1	0.49	4.8	6080	4.1	165	62	< 1	5	12.7	1890	47	4	1040	27800
TQ0506	Golf Course	sod grasses	3	O/Cl	69.2	0.23	4.6	4780	3.6	173	41	< 1	5	10.1	1680	34	4	1160	26500
TQ0507	Park/Playground	sod grasses	1	O/Cl	59.1	0.44	6.8	8950	0.7	22.8	56	< 1	14	11.5	17600	31	7	444	13600
TQ0507	Park/Playground	sod grasses	2	O	66.1	0.27	7	4940	1.2	30.1	41	< 1	22	20	20500	26	7	834	11500
TQ0507	Park/Playground	sod grasses	3	O/Cl	38.3	0.96	6.8	9690	0.5	32.3	35	< 1	13	4.8	27200	198	9	492	20100
TQ0508	Vacant Land (undeveloped)	none (rock and sand)	1	O/S/Cl	40.3	0.86	5.5	7920	6.6	271	68	< 1	12	44.9	1450	28	13	4660	32100
TQ0508	Vacant Land (undeveloped)	none (rock and sand)	2	O/S/Cl	32.8	0.83	6.1	12400	8.2	307	108	< 1	6	53.2	3210	53	18	5620	54200
TQ0508	Vacant Land (undeveloped)	none (rock and sand)	3	O/S/Cl	28.2	1.13	5.9	11800	5.3	197	74	< 1	4	27	2120	134	17	5030	33000
TQ0509	Boulevard	sod grasses	1	S/O	37.2	0.51	5.5	7380	6	146	105	< 1	7	51.2	7270	40	14	4380	25400
TQ0509	Boulevard	sod grasses	2	S/O	8.2	1.02	6.4	6720	2.3	64.4	66	< 1	5	15.3	2750	122	12	2550	22300
TQ0509	Boulevard	sod grasses	3	S/O	8.0	1.07	5.8	8240	3.9	127	92	< 1	16	22.4	5340	89	15	2530	27900
TQ0510	Park/Playground	sod grasses	1	O	44.7	0.41	6	4890	1.4	26.5	53	< 1	3	17.3	2940	58	7	1300	20100
TQ0510	Park/Playground	sod grasses	2	S/O/Cl	27.9	1.16	5.4	4600	0.9	16.1	52	< 1	2	8.1	1560	56	5	830	9970
TQ0510	Park/Playground	sod grasses	3	S	23.4	1.72	6.7	2560	< 0.1	4.9	21	< 1	2	1.3	1000	15	2	161	4510
TQ0511	Boulevard	weedy grasses, forbs	1	S/O	6.7	1.35	6.7	5560	1.2	39.5	52	< 1	3	11	5150	108	9	1780	16400
TQ0511	Boulevard	weedy grasses, forbs	2	S/O/Gr	6.2	1.19	6.5	4500	0.7	19.5	47	< 1	3	7.6	2920	53	5	796	10300
TQ0511	Boulevard	weedy grasses, forbs	3	S/O	11.1	1.10	6.6	5630	1	28.5	77	< 1	3	16.9	5110	101	8	1280	16800
TQ0512	Vacant Land (undeveloped)	native grasses/shrubs/trees	1	S/O	8.4	1.21	6.6	6750	1.7	54.7	41	< 1	3	13.7	4190	97	11	1050	19400
TQ0512	Vacant Land (undeveloped)	native grasses/shrubs/trees	2	S/O	9.3	1.12	6.5	4540	1.2	34.3	40	< 1	4	10.7	2050	19	7	954	11800
TQ0512	Vacant Land (undeveloped)	native grasses/shrubs/trees	3	S/O	8.6	0.79	6.5	5190	2.1	54.1	62	< 1	4	17.9	3970	26	10	1550	16600
TQ0513	Vacant Land	native grasses, sod grasses	1	O	45.8	0.43	5.4	5840	2.8	69.8	88	< 1	3	18.7	13200	26	9	1680	16100
TQ0513	Vacant Land	native grasses, sod grasses	2	O	45.9	0.36	5.5	6770	2.6	85.3	76	< 1	4	16.7	13300	67	9	1580	17300
TQ0513	Vacant Land	native grasses, sod grasses	3	O	32.3	0.48	5.5	7010	2.9	80.9	79	< 1	4	20.3	13300	39	10	1520	17200
TQ0514	Park/Playground	sod grasses	1	O	64.0	0.39	5.2	5000	1.7	28.7	69	< 1	7	23.5	10600	28	7	2870	12300
TQ0514	Park/Playground	sod grasses	2	O	64.6	0.24	5.2	3670	2.1	32	54	< 1	6	33.9	9580	18	6	3730	10300
TQ0514	Park/Playground	sod grasses	3	O	54.9	0.56	5.3	5560	1.3	19.9	79	< 1	5	15.1	10400	22	6	2260	11100
TQ0515	Boulevard	sod grasses	1	O	40.4	0.49	5.5	6820	1.8	14.8	83	< 1	5	12.3	9310	27	5	1300	9730
TQ0515	Boulevard	sod grasses	2	O	38.4	0.55	5.4	7350	0.7	14.7	76	< 1	3	13.2	6410	93	6	1130	11000
TQ0515	Boulevard	sod grasses	3	O	41.7	0.51	5.7	5570	0.7	15.8	59	< 1	3	11.3	5510	33	5	1320	9540
TQ0516	Vacant Land (undeveloped)	native grasses, forbs	1	S/O	7.0	0.97	7.2	4590	0.6	24.5	54	< 1	4	6.1	2310	39	6	701	10100
TQ0516	Vacant Land (undeveloped)	native grasses, forbs	2	S/O	8.4	0.79	6.8	4350	1	33	55	< 1	2	12	3300	64	8	1430	13200
TQ0516	Vacant Land (undeveloped)	native grasses, forbs	3	S/O	11.6	1.00	7	7610	2.6	75.8	63	< 1	11	24.7	11200	59	12	1820	24900
TQ0517	School yard	sod grasses	1	S/Si	5.0	1.16	6.8	3080	< 0.1	6.7	29	< 1	1	3	1430	13	3	314	5690
TQ0517	School yard	sod grasses	2	S	3.6	1.11	6.3	2120	< 0.1	3.7	19	< 1	1	1.8	680	8	2	156	3800
TQ0517	School yard	sod grasses	3	O/S	20.1	0.97	5.9	3900	0.6	18.6	42	< 1	2	6.3	5650	20	5	726	7960
TQ0518	Vacant Land (undeveloped)	native grasses	1	O	49.3	0.54	5.9	6630	5.4	131	23	< 1	16	36.2	6080	30	13	2960	22800
TQ0518	Vacant Land (undeveloped)	native grasses	2	O	43.7	0.65	5.5	6100	5.4	120	67	< 1	7	17.7	2520	25	10	2310	23100
TQ0518	Vacant Land (undeveloped)	native grasses	3	O	32.1	0.75	5.8	7130	4.2	119	77	< 1	4	25	3160	39	10	2410	22600

Site	Land Use	Rep #	Pb	Mg	Mn	Hg	Mo	Ni	P	K	Se	Ag	Na	Sr	S (%)	Tl	Ti	Sn	V	Zn	Zr
Flin Flon Sites																					
TQ0501	Boulevard	1	568	11400	504	898	4.3	46	887	5080	260	4	231	13	0.95	0.7	1100	< 5	58	7340	10
TQ0501	Boulevard	2	506	10900	445	834	4.8	46	743	4850	197	3.4	223	12	0.74	0.7	1060	< 5	56	6350	10
TQ0501	Boulevard	3	533	8590	356	227	3.6	32	875	4070	74.7	3.2	171	12	0.47	0.7	896	< 5	48	5300	8
TQ0502	Vacant Land	1	137	4240	141	10.6	2.7	15	1290	1710	7.3	1.3	68	23	0.69	0.2	378	< 5	25	2300	2
TQ0502	Vacant Land	2	150	3820	153	8.71	2.7	15	1370	1720	6.6	1.3	62	28	0.72	0.2	331	< 5	23	2520	2
TQ0502	Vacant Land	3	117	3920	121	8.25	2.4	14	1210	1690	5.8	1.1	69	22	0.95	0.2	363	< 5	24	2080	2
TQ0503	Boulevard	1	251	5570	189	87.3	1.9	18	980	2050	32.2	1.6	89	9	0.79	0.3	350	< 5	25	1710	< 1
TQ0503	Boulevard	2	374	5910	240	147	2.8	19	1190	2110	58.3	2.6	112	15	0.68	0.8	384	< 5	27	3130	< 1
TQ0503	Boulevard	3	286	6180	199	204	2.4	19	1130	2070	71.7	2.2	141	20	1.03	0.4	385	< 5	27	2750	< 1
TQ0504	Vacant Land (undeveloped)	1	161	7330	246	8.07	2	44	643	2250	5.8	1.2	127	12	0.68	0.2	481	< 5	34	2080	2
TQ0504	Vacant Land (undeveloped)	2	266	7410	279	21.4	4	26	666	2880	10.5	2	144	11	0.66	0.3	622	< 5	40	2500	2
TQ0504	Vacant Land (undeveloped)	3	316	6130	212	32.8	3.7	29	710	2040	14.6	2.4	106	6	0.57	0.3	481	< 5	32	2320	1
TQ0505	Vacant Land (undeveloped)	1	1990	10000	459	109	4.7	14	1180	2260	49.6	7.5	102	6	0.57	1	832	6	67	3260	1
TQ0505	Vacant Land (undeveloped)	2	1140	7350	467	43.4	3.6	17	1170	2230	25.1	4.9	87	7	0.36	1	666	77	47	3700	1
TQ0505	Vacant Land (undeveloped)	3	1210	10800	495	82.6	4	15	1060	3050	39	7	161	8	0.33	1.1	1060	8	77	3250	2
TQ0506	Golf Course	1	327	2260	58	10.8	1.2	10	4160	754	7.4	1.4	272	5	0.22	0.3	197	< 5	25	1290	< 1
TQ0506	Golf Course	2	352	2530	61	16.2	1.7	15	5670	801	9.3	1.5	577	8	0.24	0.3	118	< 5	30	1400	< 1
TQ0506	Golf Course	3	324	2140	58	8.9	2	12	3590	840	8.5	1.7	572	6	0.17	0.2	127	< 5	20	1230	< 1
TQ0507	Park/Playground	1	722	8080	448	3.27	0.7	16	1500	1860	2.6	0.4	341	28	0.19	0.1	427	< 5	24	859	2
TQ0507	Park/Playground	2	132	8350	461	6.48	1.2	17	1890	1260	4.5	0.7	277	33	0.29	0.1	192	< 5	16	1230	< 1
TQ0507	Park/Playground	3	65.6	18900	231	1.27	2.2	75	917	1500	2.1	0.4	180	13	0.14	< 0.1	374	< 5	39	658	< 1
TQ0508	Vacant Land (undeveloped)	1	733	3580	137	516	4	17	480	509	128	5.8	79	6	0.41	0.4	549	19	28	7740	< 1
TQ0508	Vacant Land (undeveloped)	2	1120	5600	296	645	5.6	36	769	1090	136	7.3	94	11	[illegible]	0.8	639	69	42	16500	1
TQ0508	Vacant Land (undeveloped)	3	654	6510	256	525	5.7	61	843	1450	123	5	103	8	0.37	0.5	624	6	43	6190	1
TQ0509	Boulevard	1	619	4530	226	428	4.2	24	2090	1400	99.7	3.8	113	22	0.69	0.6	177	14	23	9210	1
TQ0509	Boulevard	2	305	4640	172	248	4.3	65	445	1910	49.8	2	115	9	0.41	0.3	374	< 5	24	3490	2
TQ0509	Boulevard	3	434	5810	215	398	3	48	1440	1690	79.7	2.5	242	27	0.59	0.5	299	< 5	26	6190	< 1
TQ0510	Park/Playground	1	157	3180	222	29.8	5.1	35	833	920	8	0.9	78	11	0.12	0.2	250	< 5	18	1340	< 1
TQ0510	Park/Playground	2	125	2760	78	78.3	1.7	30	865	1520	13.7	0.7	58	6	0.23	0.2	280	< 5	18	1190	< 1
TQ0510	Park/Playground	3	14.4	1370	36	2.11	0.3	< 7	247	648	0.7	0.1	45	3	0.03	< 0.1	165	< 5	10	165	< 1
TQ0511	Boulevard	1	270	4690	161	85.5	2.7	63	447	1590	18.7	1.4	95	10	0.41	0.2	258	< 5	20	2420	1
TQ0511	Boulevard	2	136	3310	112	35.4	1.5	28	354	1280	10.2	0.7	64	7	0.48	0.1	218	< 5	16	1500	< 1
TQ0511	Boulevard	3	242	4230	177	58.1	2.9	52	649	1900	13.9	0.9	86	13	0.26	0.2	252	< 5	20	1750	1
TQ0512	Vacant Land (undeveloped)	1	242	5680	197	51.1	2.2	51	480	1330	14.1	1.1	62	7	0.62	0.2	238	< 5	23	4080	< 1
TQ0512	Vacant Land (undeveloped)	2	196	3180	124	41.5	0.9	12	376	1080	10.8	1	67	8	0.53	0.2	167	< 5	15	2520	< 1
TQ0512	Vacant Land (undeveloped)	3	323	3700	162	93	1.5	17	688	1430	22.4	1.4	70	12	1.14	0.3	203	< 5	18	4150	< 1
TQ0513	Vacant Land	1	341	3730	122	49	2.5	16	984	1240	16.5	1.3	64	19	0.54	0.3	154	< 5	16	2250	1
TQ0513	Vacant Land	2	294	4950	111	59.6	3	34	812	1100	18.2	1.7	65	19	0.45	0.3	186	< 5	18	1820	2
TQ0513	Vacant Land	3	305	4440	150	46.9	2.1	20	832	1110	17.2	1.4	117	18	0.38	0.2	148	< 5	18	2440	< 1
TQ0514	Park/Playground	1	201	2690	506	106	4.2	17	1780	1020	23.9	1.6	75	23	0.69	0.2	136	< 5	18	2010	3
TQ0514	Park/Playground	2	265	2210	827	52.5	4.5	13	1840	1030	17.4	2	42	23	0.58	0.2	80	< 5	14	2820	< 1
TQ0514	Park/Playground	3	183	2930	341	47.5	3.3	18	1120	1260	12.6	1.2	54	23	0.44	0.2	228	< 5	20	1720	4
TQ0515	Boulevard	1	115	3430	119	6.93	2	19	1030	1520	4.1	0.7	50	54	0.44	0.2	272	< 5	22	1150	5
TQ0515	Boulevard	2	91.9	3760	143	5.99	2.8	48	713	1870	3.7	0.6	66	34	0.36	0.2	310	< 5	23	1020	5
TQ0515	Boulevard	3	107	3330	131	8.91	2.1	20	674	1550	4.3	0.7	59	25	0.3	0.1	222	< 5	18	1060	3
TQ0516	Vacant Land (undeveloped)	1	139	3010	120	25.4	1.2	20	224	1450	7	0.6	52	15	0.28	0.2	309	< 5	18	1390	1
TQ0516	Vacant Land (undeveloped)	2	209	3060	158	55.9	2.4	35	303	1060	11.7	1.1	46	18	0.25	0.2	248	< 5	17	1950	< 1
TQ0516	Vacant Land (undeveloped)	3	476	5080	386	139	2.7	38	2180	996	28.9	1.8	200	35	0.35	0.3	217	5	26	4750	1
TQ0517	School yard	1	36.1	1980	71	4.06	0.5	8	173	1000	1.3	0.2	38	4	0.36	< 0.1	200	< 5	10	290	1
TQ0517	School yard	2	22.6	1370	44	1.94	0.3	6	119	699	0.6	0.1	27	2	0.03	< 0.1	139	< 5	7	163	< 1
TQ0517	School yard	3	73.4	2330	105	32.5	1.3	15	282	1110	9.9	0.5	46	18	0.03	0.1	216	< 5	13	827	3
TQ0518	Vacant Land (undeveloped)	1	826	3420	268	79.5	4.1	23	2200	709	30.7	3.2	231	60	0.07	0.6	107	17	18	9290	1
TQ0518	Vacant Land (undeveloped)	2	705	3480	209	91	3.6	16	925	717	23.5	2.5	95	20	0.46	0.5	203	< 5	20	4400	< 1
TQ0518	Vacant Land (undeveloped)	3	671	3880	177	92.2	2.2	24	1300	924	24.5	2.8	104	10	0.23	0.5	189	13	21	4950	< 1

Site	Land Use	Vegetation	Rep #	Texture	Moisture (%)	Density (g/cm3)	pH	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe
TQ0519	Park/Playground	sod grasses	1	S/O	14.2	1.20	5.2	2840	< 0.1	9.7	37	< 1	< 1	3.5	800	18	4	277	6480
TQ0519	Park/Playground	sod grasses	2	S/O	19.2	1.10	5.3	3790	0.6	17.3	37	< 1	< 1	5.1	1730	21	4	374	8320
TQ0519	Park/Playground	sod grasses	3	S/O	6.2	1.10	5.3	2950	0.6	13.4	34	< 1	< 1	5.2	1740	19	3	406	6570
TQ0520	Boulevard	weedy grasses, forbs	1	O	39.9	0.36	6.9	4690	0.9	51.6	38	< 1	3	9.1	10600	60	11	814	16100
TQ0520	Boulevard	weedy grasses, forbs	2	O	44.9	0.56	7.5	4730	1.2	48.2	36	< 1	7	16.1	11600	31	9	873	13300
TQ0520	Boulevard	weedy grasses, forbs	3	O/Cl/S	18.6	1.07	7	4100	0.6	35.2	37	< 1	2	6.2	6390	32	7	496	11300
TQ0521	Golf Course	sod grasses	1	O	55.7	0.46	5.8	10200	1	25.2	72	< 1	5	16.7	9180	50	11	829	19400
TQ0521	Golf Course	sod grasses	2	O	56.2	0.53	5.2	6060	1.3	29.9	31	< 1	4	14.1	7090	36	7	834	13600
TQ0521	Golf Course	sod grasses	3	O	43.4	0.38	5.5	4550	1.9	45.1	58	< 1	6	18.4	12600	41	8	1090	12600
TQ0522	Boulevard	sod grasses	1	S/O	12.8	0.76	6.9	11100	1.2	27.7	91	< 1	6	14.3	7520	110	11	1980	21900
TQ0522	Boulevard	sod grasses	2	S/Si/O	5.5	1.03	6.9	9270	1	29.5	74	< 1	4	13.4	5740	54	11	1410	22000
TQ0522	Boulevard	sod grasses	3	S/O/Gr	3.1	1.54	7	4570	0.6	14.1	48	< 1	8	6.2	4250	41	6	805	11000
TQ0523	Golf Course	sod grasses	1	O	62.3	0.38	5.1	5840	4.6	99.5	71	< 1	4	36.5	5230	25	13	1700	17400
TQ0523	Golf Course	sod grasses	2	O	70.1	0.24	5.3	3220	4.4	97.5	33	< 1	4	61	5820	11	45	3210	14600
TQ0523	Golf Course	sod grasses	3	O	50.9	0.43	4.2	3580	2.6	34.3	50	< 1	3	24.9	4170	17	7	1200	10300
TQ0524	Vacant Land	weedy grasses, forbs	1	S/O/Cl	17.5	1.17	7.2	9400	< 0.1	9.2	89	< 1	4	2.5	4880	47	8	319	15800
TQ0524	Vacant Land	weedy grasses, forbs	2	S/O/Cl	20.2	1.18	7.6	9460	< 0.1	8.3	94	< 1	6	3.1	8250	85	8	384	15600
TQ0524	Vacant Land	weedy grasses, forbs	3	S/O/Cl	20.3	1.36	7.6	11200	< 0.1	7.8	107	< 1	4	2.9	6020	56	9	320	18000
TQ0525	Park/Playground	sod grasses	1	S/O	33.8	0.70	7.6	5540	0.7	25.9	83	< 1	10	13.8	13600	47	7	1200	11900
TQ0525	Park/Playground	sod grasses	2	S/O	40.7	1.01	7.5	3430	0.7	29.9	32	< 1	4	8.4	9910	34	5	814	8580
TQ0525	Park/Playground	sod grasses	3	S/O	69.3	0.27	6.9	2780	2.6	46	45	< 1	16	27	11300	24	6	2560	9270
TQ0526	Boulevard	sod grasses	1	O	41.9	0.37	6.3	4060	1.6	26.2	64	< 1	8	19.7	17300	17	6	1720	9730
TQ0526	Boulevard	sod grasses	2	O	31.0	0.37	6.2	4440	1.3	21.7	63	< 1	7	16.6	9670	24	5	1410	9230
TQ0526	Boulevard	sod grasses	3	O	40.1	0.45	5.8	5270	1.2	20	63	< 1	6	16.6	14100	26	6	1410	10300
TQ0527	Park/Playground	sod grasses	1	S/Si/O	20.9	0.96	6	5100	0.8	22.9	46	< 1	7	4.4	1650	38	4	736	10000
TQ0527	Park/Playground	sod grasses	2	S/Gr	13.1	1.34	6	3910	1.3	21	73	< 1	3	5.5	1140	31	4	608	9570
TQ0527	Park/Playground	sod grasses	3	S	5.0	1.73	6.3	3150	< 0.1	10.5	37	< 1	1	3.2	920	18	3	345	6920
TQ0528	Boulevard	weedy grasses/shrubs/trees	1	S/Gr/O	3.2	0.90	6.8	5700	0.5	12.8	62	< 1	2	6.1	2280	143	7	694	14300
TQ0528	Boulevard	weedy grasses/shrubs/trees	2	S/Gr/O	4.8	1.25	7	5150	< 0.1	6.9	239	< 1	1	3.5	3450	37	6	309	9970
TQ0528	Boulevard	weedy grasses/shrubs/trees	3	S/Gr/O	6.8	0.99	6.8	5390	< 0.1	7.4	61	< 1	2	3.7	2010	36	7	430	9960
TQ0529	Vacant Land	sod grasses	1	S/Si	6.1	1.20	7.1	6450	< 0.1	16.8	60	< 1	3	5.3	5800	44	8	585	14000
TQ0529	Vacant Land	sod grasses	2	S/Si	11.5	1.25	7	7990	< 0.1	15	84	< 1	5	5.4	4170	67	8	670	16000
TQ0529	Vacant Land	sod grasses	3	S/Si	3.0	1.03	6.9	5020	< 0.1	12.8	52	< 1	2	4.2	3600	54	6	522	11800
TQ0530	Boulevard	sod grasses	1	S/Gr	3.3	1.05	6.8	5610	< 0.1	9.4	63	< 1	1	4.4	1960	49	5	498	10400
TQ0530	Boulevard	sod grasses	2	S/Gr	6.6	1.17	6.8	4180	< 0.1	4	46	< 1	1	2.8	1590	21	4	201	7310
TQ0530	Boulevard	sod grasses	3	S/Gr	3.3	1.35	7.4	4760	< 0.1	5.4	55	< 1	1	3	2600	34	4	242	8370
TQ0531	Park/Playground	sod grasses	1	S/O/Cl	16.3	1.59	8	5570	< 0.1	13.9	24	< 1	3	3.8	5560	36	6	351	12300
TQ0531	Park/Playground	sod grasses	2	O/Si	32.2	0.78	7.7	6570	1.2	31.9	31	< 1	8	18.4	13800	55	7	1280	13300
TQ0531	Park/Playground	sod grasses	3	O/Si	33.5	0.86	7.7	6650	1.4	34.5	39	< 1	6	10.4	11400	26	7	740	13700
TQ0532	Vacant Land	weedy grasses, forbs	1	S/Si	9.4	0.85	7	8780	< 0.1	12.4	76	< 1	3	7.5	3890	67	7	760	14900
TQ0532	Vacant Land	weedy grasses, forbs	2	S/Si	6.4	0.89	7.1	7170	0.7	17.8	47	< 1	3	7.7	5870	29	7	764	14400
TQ0532	Vacant Land	weedy grasses, forbs	3	S/Si/Gr	8.0	1.06	7.3	11400	0.5	13.5	88	< 1	4	4.8	7770	116	9	500	18000
TQ0533	Boulevard	sod grasses	1	O/Si	24.7	0.53	6.8	6100	0.8	11.8	72	< 1	5	11.1	6570	44	6	812	11400
TQ0533	Boulevard	sod grasses	2	O/Si	33.8	0.44	7.2	5040	1.3	20.9	73	< 1	5	15.2	8100	75	8	1310	13500
TQ0533	Boulevard	sod grasses	3	O/Si	24.5	0.55	6.5	5370	0.9	14.9	69	< 1	12	10.9	5870	49	6	913	10700
TQ0534	Boulevard	sod grasses	1	O	60.5	0.44	5.8	10000	1.9	44.7	81	< 1	6	12.8	7700	35	13	1800	20900
TQ0534	Boulevard	sod grasses	2	O	43.5	0.57	6.3	10800	0.7	27.6	84	< 1	6	6.9	10000	33	9	743	17800
TQ0534	Boulevard	sod grasses	3	O	35.0	0.51	5.8	7280	1	28.7	66	< 1	7	7.5	13600	25	7	765	13600
TQ0535	Boulevard	sod grasses	1	O	47.8	0.43	6.1	11700	0.7	16.2	114	< 1	7	11.6	8410	47	8	717	16800
TQ0535	Boulevard	sod grasses	2	O	37.2	0.50	6.4	17200	0.8	17.9	114	< 1	12	13.1	8670	69	11	743	23000
TQ0535	Boulevard	sod grasses	3	O	38.1	0.48	6.3	12500	0.7	16.7	87	< 1	8	12	6900	65	9	697	18300
TQ0536	Park/Playground	sod grasses	1	S/Gr	1.7	1.63	7.5	5970	< 0.1	3.3	35	< 1	2	1.7	1190	51	4	74	8050
TQ0536	Park/Playground	sod grasses	2	S	1.0	1.07	7.1	5100	< 0.1	3.3	33	< 1	2	2.1	992	40	3	76	7330
TQ0536	Park/Playground	sod grasses	3	S	2.4	1.17	6.6	6230	< 0.1	4.6	35	< 1	2	1.9	842	104	4	115	8240

Site	Land Use	Rep #	Pb	Mg	Mn	Hg	Mo	Ni	P	K	Se	Ag	Na	Sr	S (%)	Ti	Ti	Sn	V	Zn	Zr
TQ0519	Park/Playground	1	47.7	1800	60	3.56	0.5	19	237	1100	1.4	0.2	34	3	0.22	< 0.1	217	< 5	12	374	< 1
TQ0519	Park/Playground	2	69.9	2160	69	11.6	0.8	13	399	1210	3.4	0.3	38	5	0.06	0.1	211	< 5	14	805	< 1
TQ0519	Park/Playground	3	78	1620	56	7.99	0.9	11	326	1060	2.9	0.4	29	5	0.14	0.1	172	< 5	11	728	< 1
TQ0520	Boulevard	1	127	7720	161	2.61	3	41	311	1830	3.1	0.6	87	11	0.13	0.2	294	< 5	20	1150	1
TQ0520	Boulevard	2	149	6540	187	7.39	2	23	499	1300	4.6	0.7	214	20	0.65	0.2	208	< 5	17	1330	< 1
TQ0520	Boulevard	3	90.4	5300	126	5	1.7	20	286	1300	2.3	0.4	80	7	0.35	0.2	231	< 5	15	709	< 1
TQ0521	Golf Course	1	234	6970	326	16.9	1.4	27	1000	3180	3.2	0.7	166	20	0.61	0.4	469	< 5	33	1370	9
TQ0521	Golf Course	2	237	4380	227	21.2	2.1	14	1450	1630	7.6	1	87	17	0.38	0.2	144	< 5	20	1190	3
TQ0521	Golf Course	3	287	3760	263	33.7	2.5	14	1200	1570	10.3	1.1	75	21	0.31	0.2	124	< 5	17	1610	< 1
TQ0522	Boulevard	1	203	8340	270	46.1	3.2	59	493	3290	11.7	1.4	119	13	0.23	0.3	625	< 5	37	2320	3
TQ0522	Boulevard	2	157	7220	264	29.4	1.8	31	363	2100	7.2	0.9	109	12	0.21	0.2	416	16	30	2230	2
TQ0522	Boulevard	3	113	3910	140	19.3	1.4	24	271	1270	4.6	0.6	119	12	0.18	0.1	229	< 5	16	1630	< 1
TQ0523	Golf Course	1	606	2910	290	33.7	2.1	15	1270	1160	13.2	1.9	124	14	0.3	0.5	95	< 5	17	6600	< 1
TQ0523	Golf Course	2	529	2310	996	42.3	2.7	10	1210	984	15.3	2.4	70	9	0.46	0.8	20	< 5	11	5680	< 1
TQ0523	Golf Course	3	338	2000	210	30.3	2.6	10	1190	1270	9.3	1.2	120	9	0.4	0.3	102	< 5	11	3040	< 1
TQ0524	Vacant Land	1	41.2	6100	186	3.09	0.8	28	320	2850	1.1	0.2	139	15	0.07	0.2	635	< 5	31	406	6
TQ0524	Vacant Land	2	38.4	6550	207	5	1.4	48	367	3220	1.6	0.3	177	27	0.09	0.2	664	< 5	32	356	5
TQ0524	Vacant Land	3	37.3	7280	227	2.13	1.2	32	348	3660	1	0.2	180	18	0.14	0.3	744	< 5	36	358	8
TQ0525	Park/Playground	1	143	4400	292	16.9	1.9	28	316	2440	5.6	0.8	96	31	0.08	0.2	421	< 5	21	1270	1
TQ0525	Park/Playground	2	105	2340	203	34.2	1.2	18	375	736	7.1	0.6	53	15	0.12	0.1	210	< 5	13	1560	< 1
TQ0525	Park/Playground	3	265	3310	209	60.9	4.3	14	650	1170	20.6	1.8	120	30	0.35	0.2	43	< 5	10	4280	< 1
TQ0526	Boulevard	1	228	3720	154	9.78	2.2	12	995	1610	14.2	1.1	46	27	0.8	0.2	110	< 5	14	2380	< 1
TQ0526	Boulevard	2	173	3560	132	11.7	2.3	15	884	1820	9.7	0.9	46	18	0.47	0.2	193	< 5	15	1810	< 1
TQ0526	Boulevard	3	172	6970	196	15	2.1	16	887	2090	11.4	0.9	62	18	0.49	0.3	266	< 5	17	1590	2
TQ0527	Park/Playground	1	119	2720	78	29.4	1.7	22	690	1550	6.9	0.6	51	5	0.11	0.1	185	< 5	16	709	< 1
TQ0527	Park/Playground	2	178	2190	73	21.8	1.1	19	268	993	5.5	0.5	138	16	0.12	0.1	228	< 5	15	896	< 1
TQ0527	Park/Playground	3	61.1	1970	67	9.31	0.6	11	193	1110	2.4	0.2	39	3	0.11	< 0.1	243	< 5	13	642	< 1
TQ0528	Boulevard	1	136	3840	148	16.5	2.8	73	336	1920	4.3	0.5	94	8	0.19	0.1	370	< 5	23	957	< 1
TQ0528	Boulevard	2	225	4430	128	2.61	1	20	229	1940	0.9	0.2	85	9	0.07	0.1	395	< 5	21	516	< 1
TQ0528	Boulevard	3	56.1	3140	244	4.52	1.2	22	315	1940	1.4	0.3	79	9	0.13	0.1	343	< 5	19	419	1
TQ0529	Vacant Land	1	91.4	6320	199	5.48	1.6	29	340	1780	2.1	0.4	111	9	0.13	0.1	364	< 5	24	1080	1
TQ0529	Vacant Land	2	97.4	6320	192	8.34	1.8	35	392	2410	2.7	0.5	116	10	0.1	0.2	490	< 5	32	964	2
TQ0529	Vacant Land	3	92.3	4270	120	5.96	1.4	27	387	1680	3.8	0.4	63	7	0.18	0.1	314	< 5	20	910	< 1
TQ0530	Boulevard	1	74.1	3790	96	2.57	1.3	25	267	1900	1.5	0.3	71	6	0.09	0.1	387	< 5	21	469	< 1
TQ0530	Boulevard	2	32.6	2920	84	1.66	0.5	12	230	1700	0.6	0.1	55	4	0.07	< 0.1	292	< 5	16	249	< 1
TQ0530	Boulevard	3	40.1	3470	88	2.13	0.7	18	218	1880	0.7	0.2	70	6	0.18	0.1	343	< 5	19	299	< 1
TQ0531	Park/Playground	1	53.3	5040	147	11.2	0.9	22	289	876	2.4	0.3	54	10	0.13	0.1	183	< 5	18	758	< 1
TQ0531	Park/Playground	2	184	7020	247	26.5	1.8	32	618	1300	8	1	185	30	0.17	0.2	219	< 5	20	2650	3
TQ0531	Park/Playground	3	129	6720	205	27.9	1	17	501	1370	7	0.7	321	22	0.24	0.2	256	< 5	21	3050	3
TQ0532	Vacant Land	1	96.8	5140	191	19.3	1.4	34	380	2920	4.6	0.5	87	9	0.06	0.2	504	< 5	27	894	3
TQ0532	Vacant Land	2	107	5960	190	14.6	0.9	19	333	1480	3.9	0.6	56	8	0.34	0.1	286	< 5	23	1730	1
TQ0532	Vacant Land	3	59.7	6860	248	9.31	1.7	57	353	2930	2.7	0.4	104	10	0.07	0.2	614	< 5	34	889	3
TQ0533	Boulevard	1	134	4550	158	12.2	1.5	24	820	2370	4.4	0.5	83	17	0.2	0.2	353	< 5	23	1180	< 1
TQ0533	Boulevard	2	187	4410	157	27.9	2.5	38	884	1780	8.3	0.9	78	26	0.35	0.2	248	< 5	19	2020	1
TQ0533	Boulevard	3	157	3930	143	26	1.5	22	674	1980	6	0.6	174	23	0.25	0.1	280	< 5	18	1430	1
TQ0534	Boulevard	1	334	6570	283	9	2.3	26	1080	1940	5.2	1.3	228	19	0.45	0.3	367	< 5	28	3300	3
TQ0534	Boulevard	2	89.1	6750	220	1.66	1.8	21	463	2550	2.2	0.5	238	19	0.56	0.3	567	< 5	30	1550	8
TQ0534	Boulevard	3	89.8	5510	191	2.13	2.1	17	489	1550	2.5	0.6	331	25	0.61	0.2	347	< 5	22	1650	5
TQ0535	Boulevard	1	138	7170	239	11.7	1.3	26	836	4010	3.9	0.5	143	25	0.24	0.2	569	< 5	35	1350	5
TQ0535	Boulevard	2	118	9910	311	10.7	1.3	34	1040	4890	4.5	0.6	214	25	0.26	0.2	866	< 5	51	1310	8
TQ0535	Boulevard	3	103	7300	244	6.92	1.4	31	999	3880	3.8	0.5	146	18	0.25	0.2	655	< 5	40	1060	3
TQ0536	Park/Playground	1	10	3340	93	0.05	0.6	23	317	1710	< 0.2	< 0.1	56	3	0.07	< 0.1	360	< 5	19	117	1
TQ0536	Park/Playground	2	11.4	3010	79	0.07	0.5	18	326	1370	< 0.2	< 0.1	40	3	0.08	< 0.1	285	< 5	17	91	1
TQ0536	Park/Playground	3	13	3060	79	0.07	1.3	44	362	1570	0.3	< 0.1	52	2	0.05	< 0.1	427	< 5	20	89	1

Site	Land Use	Vegetation	Rep #	Texture	Moisture (%)	Density (g/cm3)	pH	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe
TQ0537	Vacant Land (undeveloped)	native grasses/shrubs/trees	1	O	40.2	0.59	6.6	5960	6.5	110	94	< 1	11	71.7	16000	113	17	4460	27900
TQ0537	Vacant Land (undeveloped)	native grasses/shrubs/trees	2	O	47.2	0.38	6.6	5490	7.6	117	103	< 1	15	83.5	20500	32	11	4650	17700
TQ0537	Vacant Land (undeveloped)	native grasses/shrubs/trees	3	O	38.4	0.31	5.8	6200	5.1	75.6	73	< 1	9	57.6	11100	33	9	2890	18000
TQ0538	Vacant Land (undeveloped)	native grasses	1	O/S	32.4	0.92	4.9	15400	3.4	98.6	58	< 1	3	24.8	907	38	9	1560	28000
TQ0538	Vacant Land (undeveloped)	native grasses	2	O	34.7	0.55	4.5	8580	8.1	96.3	169	< 1	3	44.8	2330	16	16	3440	18800
TQ0538	Vacant Land (undeveloped)	native grasses	3	O	30.6	0.42	4.8	10900	7.5	105	136	< 1	5	57.7	2450	18	17	3340	21800
TQ0539	Boulevard	sod grasses	1	O	36.7	0.55	6.6	9000	2.8	34.6	115	< 1	18	88.5	10200	35	9	1720	21300
TQ0539	Boulevard	sod grasses	2	O	35.0	0.51	6.4	8330	1.5	26.8	81	< 1	9	38.7	7230	36	8	1430	17000
TQ0539	Boulevard	sod grasses	3	O	24.0	0.49	6.3	6720	1.1	15.8	64	< 1	7	20.1	6430	40	6	1260	11600
TQ0540	Vacant Land (undeveloped)	native grasses	1	O	31.1	0.37	6.5	18000	3	22.7	123	< 1	41	29	17200	48	10	1990	23800
TQ0540	Vacant Land (undeveloped)	native grasses	2	O	26.9	0.25	6.9	3990	2.8	29.3	51	< 1	62	53.6	28500	15	8	2640	9120
TQ0540	Vacant Land (undeveloped)	native grasses	3	O	37.6	0.53	6.1	24000	1.8	21.4	128	< 1	23	17.4	9860	54	11	1150	24400
TQ0541	Park/Playground	sod grasses	1	O/Cl	37.7	0.93	6.7	7690	< 0.1	4.5	98	< 1	6	0.9	16300	17	5	54	10300
TQ0541	Park/Playground	sod grasses	2	O/Cl	47.2	0.83	6.7	6560	< 0.1	3.8	62	< 1	7	1.1	12900	42	4	56	7780
TQ0541	Park/Playground	sod grasses	3	O/Cl	42.0	0.89	6.9	7970	< 0.1	4.5	104	< 1	6	0.9	21800	16	5	53	10400
TQ0542	Park/Playground	sod grasses, forbs	1	S	16.6	1.56	7.4	4950	< 0.1	3.6	25	< 1	3	1.4	1600	21	3	103	6580
TQ0542	Park/Playground	sod grasses, forbs	2	O/S	30.6	0.94	7	4630	0.7	12.4	58	< 1	6	5.8	3680	29	5	417	17100
TQ0542	Park/Playground	sod grasses, forbs	3	S	21.3	1.53	7.7	5120	< 0.1	7.1	19	< 1	4	2	2140	25	5	139	9280
TQ0543	Park/Playground	sod grasses	1	O	62.3	0.46	6.1	5230	0.8	9.5	64	< 1	11	11	10600	37	5	833	9390
TQ0543	Park/Playground	sod grasses	2	O	66.5	0.37	6.1	5010	0.7	10.1	61	< 1	11	13.1	13100	23	4	897	8320
TQ0543	Park/Playground	sod grasses	3	O	70.4	0.24	6.1	6900	0.9	14.6	75	< 1	15	19	15600	23	6	1170	9610
TQ0544	Vacant Land (undeveloped)	native grasses	1	O/Si	40.3	0.45	4.8	11100	4.9	151	83	< 1	5	15.1	1100	31	6	2160	18800
TQ0544	Vacant Land (undeveloped)	native grasses	2	O/Si	41.0	0.55	4.7	10200	4.1	92.1	68	< 1	8	14.1	1250	54	6	1500	15800
TQ0544	Vacant Land (undeveloped)	native grasses	3	O/Si	31.7	0.69	4.8	5170	3.5	83.1	54	< 1	3	15.5	715	36	4	1390	11500
TQ0545	Boulevard	sod grasses, forbs	1	O/Si	23.1	0.51	6.6	19700	0.8	19.1	157	< 1	16	11.3	10200	56	13	1410	21800
TQ0545	Boulevard	sod grasses, forbs	2	S/O	6.6	1.23	6.9	6560	< 0.1	4.8	48	< 1	3	2.4	2890	78	5	138	8560
TQ0545	Boulevard	sod grasses, forbs	3	O/S	29.6	0.73	6.2	7470	< 0.1	7.5	60	< 1	7	4	10900	49	4	250	8220
TQ0546	Vacant Land (undeveloped)	native grasses	1	O/S/Cl	39.6	0.79	5.4	2260	3.1	36.9	88	< 1	4	27.4	2500	23	5	1270	6670
TQ0546	Vacant Land (undeveloped)	native grasses	2	O	48.6	0.50	5.4	3550	6.2	73.6	95	< 1	4	43.4	2580	51	7	2610	12900
TQ0546	Vacant Land (undeveloped)	native grasses	3	O/Cl	50.2	0.60	5.1	2130	3.2	38.6	59	< 1	4	20.8	1520	44	5	1340	8650
TQ0547	Park/Playground	sod grasses, forbs, trees	1	O	16.5	0.68	6.2	7990	< 0.1	6.4	62	< 1	6	5.1	4920	96	6	299	11000
TQ0547	Park/Playground	sod grasses, forbs, trees	2	O	38.8	0.38	6.3	3350	1.3	14.5	49	< 1	13	17.4	10600	15	4	791	6020
TQ0547	Park/Playground	sod grasses, forbs, trees	3	O	39.5	0.46	6.3	9430	3	36.3	99	< 1	15	29.9	12800	27	9	1240	13200
TQ0548	Park/Playground	sod grasses, forbs	1	O	60.7	0.38	6	8590	0.7	11.7	88	< 1	19	12.4	17100	24	5	571	9270
TQ0548	Park/Playground	sod grasses, forbs	2	O/Cl	35.7	1.15	6.6	14800	< 0.1	8	96	< 1	8	3.4	6050	47	7	205	15100
TQ0548	Park/Playground	sod grasses, forbs	3	O/Cl	22.2	1.34	6.8	20300	< 0.1	8.8	118	< 1	8	1.6	6630	48	8	90	17800
TQ0549	Park/Playground	sod grasses, forbs, trees	1	O	41.3	0.54	5.6	12200	5.3	55.1	102	< 1	9	28.8	7230	33	10	1590	17400
TQ0549	Park/Playground	sod grasses, forbs, trees	2	O	46.8	0.37	5.5	6410	1.4	16	82	< 1	9	18.5	16800	20	5	1020	9260
TQ0549	Park/Playground	sod grasses, forbs, trees	3	O	30.5	0.48	5.7	8510	2.1	26.1	88	< 1	10	18.3	14800	24	7	1080	12500
TQ0550	Park/Playground	sod grasses	1	S/O	20.0	1.21	6	7690	0.7	13.7	60	< 1	4	8.3	2090	43	5	485	10400
TQ0550	Park/Playground	sod grasses	2	S/Si/O	16.2	1.15	5.9	5520	< 0.1	7.1	50	< 1	4	7.1	1850	35	4	378	7570
TQ0550	Park/Playground	sod grasses	3	S/O	24.4	1.33	6	9480	1.1	23.1	61	< 1	5	10.9	2570	35	7	560	12500
TQ0551	Boulevard	sod grasses, forbs	1	O/Si	18.0	0.68	6.6	11300	1.1	14.9	86	< 1	8	11.5	5510	47	8	791	15100
TQ0551	Boulevard	sod grasses, forbs	2	O/Si	30.0	0.43	6.6	15600	1.4	21.8	110	< 1	13	14.4	8080	54	10	1040	21000
TQ0551	Boulevard	sod grasses, forbs	3	O/S/Si	34.0	0.58	6.6	15300	1.1	21.7	111	< 1	15	11.9	11600	47	9	795	17300
TQ0552	Boulevard	sod grasses, forbs	1	O/Cl	55.7	0.50	7	10200	1.4	27.1	85	< 1	21	17.3	12900	34	8	1180	14300
TQ0552	Boulevard	sod grasses, forbs	2	O/Cl	42.4	0.65	6.4	15700	1.2	24.5	134	< 1	18	11.9	17300	40	8	734	17000
TQ0552	Boulevard	sod grasses, forbs	3	O/Cl	38.1	0.63	6.5	14800	1.1	26.4	119	< 1	20	13.5	15000	40	9	898	17200
TQ0553	Boulevard	sod grasses	1	O	40.5	0.49	6.7	9170	1.3	22.2	80	< 1	18	15.3	13900	31	6	1030	12200
TQ0553	Boulevard	sod grasses	2	O	23.0	0.66	6.7	10300	0.7	14	86	< 1	10	7.9	6960	42	7	663	14000
TQ0553	Boulevard	sod grasses	3	O	47.1	0.45	5.9	7970	1.1	14.6	81	< 1	13	12.1	12000	29	5	901	10200
TQ0554	School yard	sod grasses, forbs	1	Cl/O	17.9	0.78	7.5	14000	1.1	19.4	99	< 1	15	10.2	13000	47	10	484	19000
TQ0554	School yard	sod grasses, forbs	2	Cl/O	17.9	1.08	7.5	16700	1	17.7	90	< 1	13	7.6	7910	47	9	464	17500
TQ0554	School yard	sod grasses, forbs	3	O	39.2	0.41	7.5	8490	2.1	24.4	58	< 1	24	19.5	24700	28	6	1070	11500
TQ0555	School yard	sod grasses	1	S	10.7	1.11	7.1	3400	< 0.1	2.2	25	< 1	3	1.6	902	12	2	77	3820
TQ0555	School yard	sod grasses	2	S	10.2	1.21	7.1	3960	< 0.1	3.4	23	< 1	3	2.2	1310	24	2	150	4310
TQ0555	School yard	sod grasses	3	S	1.9	1.49	6.7	3700	< 0.1	1.9	23	< 1	8	1.6	773	15	2	98	4280

Site	Land Use	Rep #	Pb	Mg	Mn	Hg	Mo	Ni	P	K	Se	Ag	Na	Sr	S (%)	Tl	Ti	Sn	V	Zn	Zr
TQ0537	Vacant Land (undeveloped)	1	944	3790	324	89.6	8	51	1120	1150	26.8	5	108	28	0.71	0.5	158	< 5	19	12000	< 1
TQ0537	Vacant Land (undeveloped)	2	1190	2920	432	58.5	3.1	18	1360	946	26.4	5.3	54	33	0.59	0.5	65	< 5	13	13600	< 1
TQ0537	Vacant Land (undeveloped)	3	642	3850	302	32.2	3.5	16	903	1230	17.4	3.1	45	32	0.79	0.5	168	< 5	20	9050	< 1
TQ0538	Vacant Land (undeveloped)	1	408	3720	190	27.4	1.6	16	835	567	9.9	1.9	42	5	0.14	0.3	326	< 5	40	3470	< 1
TQ0538	Vacant Land (undeveloped)	2	1330	1820	492	27.4	2	11	1120	614	16.6	4.2	36	14	0.15	0.7	136	< 5	18	7420	< 1
TQ0538	Vacant Land (undeveloped)	3	1140	2510	648	39.4	1.9	12	1580	882	17.7	4.1	53	13	0.39	0.7	152	< 5	24	8330	< 1
TQ0539	Boulevard	1	349	5890	255	25	2.2	18	1560	2940	8.7	1.5	160	44	0.4	2.7	354	13	28	4340	2
TQ0539	Boulevard	2	202	5450	214	48.9	2	21	1120	2680	8.9	1.1	130	24	0.22	0.6	426	7	29	2960	2
TQ0539	Boulevard	3	159	4600	162	20.2	1.9	19	1030	2630	5	0.8	86	18	0.27	0.2	349	< 5	22	2110	1
TQ0540	Vacant Land (undeveloped)	1	258	9340	148	29.4	1.7	31	1450	2940	15.8	1.7	308	105	0.35	0.3	468	< 5	47	4670	3
TQ0540	Vacant Land (undeveloped)	2	294	4440	210	24.1	2.9	12	2070	1820	19.6	2	72	157	0.48	0.3	26	< 5	12	7260	< 1
TQ0540	Vacant Land (undeveloped)	3	196	10500	212	20.5	0.9	30	944	4370	9.2	1.1	314	53	0.17	0.4	887	< 5	49	4120	6
TQ0541	Park/Playground	1	12.8	8270	184	0.06	0.4	15	967	1480	0.5	< 0.1	79	21	0.06	< 0.1	57	< 5	19	99	2
TQ0541	Park/Playground	2	9.4	8340	118	0.07	0.7	21	719	1280	0.4	< 0.1	81	15	0.06	< 0.1	137	< 5	18	90	2
TQ0541	Park/Playground	3	11.3	10800	216	0.08	0.4	15	1130	1490	0.5	< 0.1	80	23	0.17	< 0.1	48	< 5	19	88	3
TQ0542	Park/Playground	1	10.4	3110	109	0.16	0.2	8	500	1130	0.3	< 0.1	76	4	0.14	< 0.1	266	< 5	16	90	< 1
TQ0542	Park/Playground	2	68.8	3830	156	5.83	1.3	16	673	737	2.4	0.4	92	10	0.03	< 0.1	242	< 5	16	1070	< 1
TQ0542	Park/Playground	3	14.5	4010	247	0.23	0.3	10	473	730	0.3	< 0.1	66	6	0.72	< 0.1	218	< 5	18	129	< 1
TQ0543	Park/Playground	1	102	3840	326	7.85	1.8	19	2800	1550	3.6	0.5	264	22	0.56	0.1	197	< 5	18	674	< 1
TQ0543	Park/Playground	2	102	3240	317	6.34	1.9	14	2210	1060	3.7	0.5	276	24	0.29	0.1	75	< 5	16	641	< 1
TQ0543	Park/Playground	3	135	4050	539	7.85	2	16	3200	1210	5.2	0.7	335	33	0.26	0.1	84	< 5	19	931	< 1
TQ0544	Vacant Land (undeveloped)	1	756	3690	98	29.9	1.9	16	653	807	15.4	2.9	84	8	0.28	0.5	406	< 5	26	2870	< 1
TQ0544	Vacant Land (undeveloped)	2	629	3890	109	32.5	1.9	26	749	925	12.2	2.2	86	8	0.06	0.4	384	< 5	24	2710	< 1
TQ0544	Vacant Land (undeveloped)	3	534	1840	65	18.9	1.6	16	378	588	9.5	1.9	54	5	0.05	0.3	274	< 5	17	2210	< 1
TQ0545	Boulevard	1	137	10400	371	4.83	1.3	33	1000	4900	3.8	0.9	171	24	0.04	0.3	858	< 5	47	1540	6
TQ0545	Boulevard	2	20.5	3910	93	0.63	1.3	36	404	1980	0.5	0.1	88	6	0.02	< 0.1	421	< 5	20	202	1
TQ0545	Boulevard	3	30.1	3980	118	0.23	1.3	24	457	1610	1.1	0.2	108	20	0.14	< 0.1	389	< 5	20	246	4
TQ0546	Vacant Land (undeveloped)	1	421	793	174	9.86	1.1	11	277	456	7.3	1.9	46	19	0.07	0.3	92	< 5	6	5560	< 1
TQ0546	Vacant Land (undeveloped)	2	877	1770	250	29.9	2.6	23	453	1080	15.4	3.6	56	17	0.07	0.5	236	< 5	11	8130	< 1
TQ0546	Vacant Land (undeveloped)	3	515	726	98	20.9	2.9	21	293	344	9.5	1.9	60	11	0.06	0.2	63	< 5	5	4830	< 1
TQ0547	Park/Playground	1	47.9	4890	180	1.24	1.6	47	641	2320	1.2	0.2	86	12	0.08	0.1	438	< 5	25	700	1
TQ0547	Park/Playground	2	163	3080	158	6.03	1.1	10	981	1010	4.5	0.7	49	30	0.2	0.1	73	< 5	10	3290	< 1
TQ0547	Park/Playground	3	394	5670	357	9.86	1	18	1140	2060	7.3	1.2	97	42	0.16	0.4	274	< 5	22	6960	1
TQ0548	Park/Playground	1	86.6	5440	240	6.34	2	15	1680	2630	3.7	0.5	166	33	0.27	0.2	294	< 5	21	1730	2
TQ0548	Park/Playground	2	39.7	7120	266	1.14	0.5	25	663	3130	1.2	0.2	159	16	0.11	0.2	663	< 5	33	542	4
TQ0548	Park/Playground	3	34.7	8860	281	0.43	0.2	27	537	3700	0.8	0.1	175	18	0.04	0.2	832	< 5	39	332	6
TQ0549	Park/Playground	1	695	5500	392	23.9	1.4	23	1070	2220	12.2	1.6	94	24	0.13	0.6	475	< 5	31	5840	2
TQ0549	Park/Playground	2	174	3900	172	12.4	1.6	12	1020	1390	3.5	1.2	56	40	0.06	0.2	264	< 5	19	3520	2
TQ0549	Park/Playground	3	249	4820	247	13.4	1.4	14	987	1910	7.1	1.1	72	38	0.17	0.3	385	< 5	24	3690	3
TQ0550	Park/Playground	1	102	3960	121	3.82	0.6	23	555	2110	1.9	0.4	89	7	0.05	0.2	448	< 5	22	1330	< 1
TQ0550	Park/Playground	2	65.8	3100	111	1.99	0.7	16	477	1740	1.4	0.3	64	6	0.06	< 0.1	320	< 5	17	713	< 1
TQ0550	Park/Playground	3	143	4530	175	6.34	0.6	17	732	2010	3.2	0.6	86	9	0.05	0.3	445	< 5	25	2460	< 1
TQ0551	Boulevard	1	143	6810	237	16.4	1.2	26	832	3520	5.1	0.7	146	13	0.16	0.2	607	< 5	31	2540	3
TQ0551	Boulevard	2	203	10000	282	21.4	1.7	32	1090	4230	6.1	0.8	183	20	0.23	0.3	729	< 5	40	2840	5
TQ0551	Boulevard	3	161	9580	289	15.4	1.3	27	1120	4090	4.9	0.6	181	34	0.18	0.2	691	< 5	37	2480	7
TQ0552	Boulevard	1	187	7120	210	18.4	1.6	18	908	2390	7.2	1	271	38	0.29	0.2	453	< 5	27	3140	2
TQ0552	Boulevard	2	124	8470	265	9.86	1	23	939	3650	4.4	0.5	182	60	0.23	0.2	664	< 5	35	2210	8
TQ0552	Boulevard	3	141	8780	281	13.9	1.1	23	915	4140	5.3	0.7	181	49	0.24	0.2	650	< 5	36	2670	6
TQ0553	Boulevard	1	172	6130	178	14.4	1.4	18	1200	1820	5.9	0.7	125	36	0.29	0.2	337	< 5	25	2240	1
TQ0553	Boulevard	2	109	6570	182	9.36	1.1	20	863	2960	3.3	0.5	150	17	0.19	0.2	549	< 5	29	1320	3
TQ0553	Boulevard	3	157	5220	189	8.85	1.7	14	1350	1820	4.3	0.7	102	23	0.29	0.1	320	< 5	22	1550	2
TQ0554	School yard	1	136	9570	277	3.2	0.3	27	955	3980	2	0.5	234	32	0.08	0.3	838	< 5	39	3680	3
TQ0554	School yard	2	116	11600	253	7.34	0.4	25	1010	4170	2	0.4	244	22	0.12	0.3	786	< 5	40	3000	6
TQ0554	School yard	3	214	11100	316	19.4	1	16	2080	1660	5.7	1.1	237	47	0.24	0.2	318	< 5	22	5580	2
TQ0555	School yard	1	14.1	1860	41	0.23	0.2	6	229	941	< 0.2	< 0.1	44	3	0.04	< 0.1	179	< 5	10	138	< 1
TQ0555	School yard	2	21.5	2070	46	0.43	0.5	11	329	1040	0.4	0.1	56	4	0.02	< 0.1	212	< 5	10	146	< 1
TQ0555	School yard	3	12.6	1970	45	0.33	0.2	7	244	964	0.2	< 0.1	59	3	0.02	< 0.1	190	< 5	10	124	< 1

Site	Land Use	Vegetation	Rep #	Texture	Moisture (%)	Density (g/cm3)	pH	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe
TQ0556	Vacant Land	sod grasses, forbs, trees	1	O	38.9	0.82	6	11200	1.8	31.2	75	< 1	8	16.6	6510	36	8	764	13600
TQ0556	Vacant Land	sod grasses, forbs, trees	2	O	39.5	0.53	6	12200	2.3	36.9	99	< 1	12	22.7	7650	36	9	1100	15800
TQ0556	Vacant Land	sod grasses, forbs, trees	3	O	40.8	0.62	6	10800	2	30.5	81	< 1	8	19.9	6450	28	8	1000	14100
TQ0557	Boulevard	weedy grasses, forbs	1	S	3.3	1.09	6.8	6760	< 0.1	5.2	48	< 1	4	3.4	2440	34	5	199	9550
TQ0557	Boulevard	weedy grasses, forbs	2	S/Gr	3.9	1.05	6.9	7220	< 0.1	6.4	62	< 1	6	4.1	3070	58	5	302	10500
TQ0557	Boulevard	weedy grasses, forbs	3	S/Gr	5.8	1.03	6.8	6470	< 0.1	4.5	49	< 1	4	3	2430	39	4	206	8840
TQ0558	Boulevard	sod grasses	1	O	23.3	0.62	6.7	13800	< 0.1	10.1	120	< 1	16	5.2	21700	43	7	377	14100
TQ0558	Boulevard	sod grasses	2	O	20.2	0.42	6.4	8130	0.6	11.2	101	< 1	20	8.4	25600	23	4	470	8970
TQ0558	Boulevard	sod grasses	3	O	19.1	0.50	6.8	12500	0.5	11	113	< 1	23	7.1	23300	33	6	453	12600
TQ0559	Park/Playground	sod grasses, forbs, trees	1	O	48.9	0.41	5.7	10700	1.4	14.5	77	< 1	17	17.1	11300	46	7	845	12000
TQ0559	Park/Playground	sod grasses, forbs, trees	2	O	61.2	0.41	5.6	11500	2.1	14.8	92	< 1	12	17.3	10100	40	8	1020	13800
TQ0559	Park/Playground	sod grasses, forbs, trees	3	O	66.5	0.29	5.6	4310	1.1	8.5	58	< 1	14	17	12900	19	7	764	7790
TQ0560	Park/Playground	sod grasses, forbs	1	O/Cl	28.1	0.80	6.8	19700	0.9	18.1	171	1	16	8.6	12100	48	10	555	21200
TQ0560	Park/Playground	sod grasses, forbs	2	O/Cl	31.5	0.62	6.8	12100	1	16.6	133	< 1	13	10.1	11900	26	7	638	14000
TQ0560	Park/Playground	sod grasses, forbs	3	O	26.9	0.57	6.7	13900	1.1	17.4	137	< 1	13	11.8	10500	64	8	733	16500
TQ0561	Boulevard	sod grasses	1	O	27.6	0.48	6.7	12400	0.8	12.5	153	< 1	16	13.3	11200	48	9	784	16800
TQ0561	Boulevard	sod grasses	2	O	36.9	0.52	6.6	11400	0.8	13.7	127	< 1	15	10.3	12800	51	9	709	16300
TQ0561	Boulevard	sod grasses	3	O/Cl	24.0	0.85	6.8	21500	< 0.1	8	235	1	53	5.3	14000	66	12	303	24500
TQ0562	Boulevard	sod grasses	1	O	30.7	0.48	6.3	13400	1.1	15.9	111	< 1	14	13.1	11900	48	9	900	16700
TQ0562	Boulevard	sod grasses	2	O	34.7	0.49	6.2	12600	1	14.8	121	< 1	10	11.9	9650	68	11	872	19200
TQ0562	Boulevard	sod grasses	3	O	31.3	0.53	6	12500	1	14.5	111	< 1	11	11.1	10100	40	8	811	16200
TQ0563	Park/Playground	sod grasses	1	S/O	5.0	0.98	6.7	6020	< 0.1	5.3	73	< 1	3	6.8	2010	83	7	441	11200
TQ0563	Park/Playground	sod grasses	2	O	43.2	0.36	5.5	6680	1.7	14.3	86	< 1	7	23	6960	60	12	1420	15000
TQ0563	Park/Playground	sod grasses	3	O	25.4	0.44	5.4	4260	1	9.6	72	< 1	7	16	11600	53	16	1160	16400
TQ0564	Boulevard	sod grasses, forbs	1	O	47.8	0.42	6.3	7400	0.8	16.2	68	< 1	7	11.2	8050	36	6	822	11900
TQ0564	Boulevard	sod grasses, forbs	2	O/Si	45.0	0.64	6.5	10000	0.9	14.9	80	< 1	9	6.5	9600	37	7	504	13500
TQ0564	Boulevard	sod grasses, forbs	3	O/Si	37.7	0.70	6.7	6510	3	13.7	51	< 1	9	9.6	7640	41	6	652	10700
TQ0565	Park/Playground	sod grasses, forbs	1	S	13.6	1.44	6	3960	< 0.1	4.3	33	< 1	2	2.9	1140	26	3	190	6100
TQ0565	Park/Playground	sod grasses, forbs	2	O/Si	30.8	0.65	6.4	5450	< 0.1	11.7	56	< 1	6	8.8	4160	102	5	447	8690
TQ0565	Park/Playground	sod grasses, forbs	3	O/Si	29.0	0.80	6.2	6450	< 0.1	6.2	57	< 1	6	5.9	3710	39	4	283	8690
TQ0566	Park/Playground	sod grasses	1	O/Si	33.6	0.49	5.8	7070	1.1	17	62	< 1	5	12.5	4080	47	8	702	12300
TQ0566	Park/Playground	sod grasses	2	O	38.3	0.55	5.5	4340	0.5	7	50	< 1	3	7.5	2530	24	4	396	7920
TQ0566	Park/Playground	sod grasses	3	O	51.2	0.47	6.5	6180	1.4	15.5	55	< 1	7	13.8	7160	29	6	831	10600
TQ0567	Boulevard	sod grasses	1	O	62.5	0.36	7.2	6690	2.1	56.5	47	< 1	12	15.6	18700	26	10	2020	16600
TQ0567	Boulevard	sod grasses	2	O	44.8	0.57	5.9	8040	1.3	24.4	62	< 1	5	9.3	6560	42	9	1230	15300
TQ0567	Boulevard	sod grasses	3	O	66.0	0.37	7.5	6930	2.4	58.5	57	< 1	13	17.8	17800	27	13	2950	20400
TQ0568	Boulevard	sod grasses	1	O	26.5	0.42	5.2	5380	0.8	8.8	58	< 1	5	9.5	6260	33	5	595	9970
TQ0568	Boulevard	sod grasses	2	O/S	6.5	0.89	5.4	6800	< 0.1	7.5	70	< 1	3	4.7	3300	73	6	421	12400
TQ0568	Boulevard	sod grasses	3	O/Si	28.1	0.72	5.7	5630	0.6	9	65	< 1	6	7.7	5450	70	6	547	10900
TQ0569	Vacant Land	weedy grasses, forbs	1	O	62.0	0.32	6.1	4230	1	12.8	76	< 1	10	21.2	16100	49	7	907	8960
TQ0569	Vacant Land	weedy grasses, forbs	2	O	39.5	0.38	6.5	6680	0.9	14.3	91	< 1	10	16.1	14800	36	5	919	10500
TQ0569	Vacant Land	weedy grasses, forbs	3	O	42.1	0.51	6.6	7110	1.1	12.2	88	< 1	10	12.6	11200	39	6	732	15400
TQ0570	Boulevard	weedy grasses, forbs	1	S/O	10.9	0.71	6	7930	1	14.3	82	< 1	7	11.1	7750	120	10	989	15500
TQ0570	Boulevard	weedy grasses, forbs	2	S/O	9.2	0.63	5.8	7760	0.8	14.1	73	< 1	6	9	5590	66	8	640	14000
TQ0570	Boulevard	weedy grasses, forbs	3	S/O	10.4	0.67	6.3	6940	1.3	11.7	68	< 1	8	8.2	8320	44	6	565	11600
TQ0571	Park/Playground	sod grasses	1	S/O	19.3	1.39	5.9	4690	< 0.1	7.5	39	< 1	2	3.5	1200	31	4	251	7290
TQ0571	Park/Playground	sod grasses	2	O/S	18.7	0.84	5.5	7050	0.7	9.7	65	< 1	4	8.4	2800	81	7	523	11400
TQ0571	Park/Playground	sod grasses	3	O/S	39.3	0.55	5.6	5400	0.9	10.6	58	< 1	4	10.4	3840	37	5	642	10400
TQ0572	Vacant Land (undeveloped)	native grasses	1	S/O	13.2	0.94	6.1	5940	1.6	18.7	123	< 1	24	12.4	5530	133	5	680	10700
TQ0572	Vacant Land (undeveloped)	native grasses	2	S	9.2	1.32	6	5480	0.5	22.4	27	< 1	2	4.8	1120	32	3	315	7810
TQ0572	Vacant Land (undeveloped)	native grasses	3	S/O	3.8	0.99	6.5	7820	0.7	12	112	< 1	17	7.9	5760	72	6	427	11100
TQ0573	Boulevard	sod grasses	1	Cl/O	20.9	1.17	7.3	9650	< 0.1	8	154	< 1	7	3.4	25800	27	7	217	14200
TQ0573	Boulevard	sod grasses	2	Cl/O	24.2	0.86	7.2	9810	0.5	8.7	151	< 1	8	3.2	20400	37	9	250	16300
TQ0573	Boulevard	sod grasses	3	Cl/O	19.7	0.98	7.3	9480	< 0.1	8.4	155	< 1	7	3.6	23500	28	8	256	16200
TQ0574	Cemetery	sod grasses, forbs	1	S/O	9.7	0.74	6.6	13000	< 0.1	8.1	94	< 1	10	9.6	7140	213	11	312	20600
TQ0574	Cemetery	sod grasses, forbs	2	S/O	22.5	0.61	6.7	16400	< 0.1	11.8	100	< 1	13	8.9	8630	126	12	374	23600
TQ0574	Cemetery	sod grasses, forbs	3	S/O	17.6	0.80	6.4	15400	< 0.1	10.5	97	< 1	15	7.8	10900	63	10	356	20200

Site	Land Use	Rep #	Pb	Mg	Mn	Hg	Mo	Ni	P	K	Se	Ag	Na	Sr	S (%)	Tl	Ti	Sn	V	Zn	Zr
TQ0556	Vacant Land	1	255	5830	318	7.34	0.7	18	1080	2210	4.6	0.8	128	24	0.12	0.3	468	< 5	28	4160	1
TQ0556	Vacant Land	2	304	6500	353	11.9	1.1	21	1160	2450	6.4	1.1	131	30	0.23	0.4	436	< 5	30	5620	2
TQ0556	Vacant Land	3	270	5440	351	11.9	0.9	16	1030	1690	5.9	1.1	98	22	0.06	0.3	427	< 5	27	4850	1
TQ0557	Boulevard	1	45.5	4190	119	1.14	0.6	17	400	2110	0.7	0.2	84	6	0.08	< 0.1	395	< 5	21	587	< 1
TQ0557	Boulevard	2	46.6	4610	114	2.81	1	25	589	2450	1	0.2	106	7	0.05	0.1	469	< 5	25	411	< 1
TQ0557	Boulevard	3	37.5	4130	103	0.12	0.8	19	458	2050	0.7	0.2	76	5	0.36	< 0.1	386	< 5	20	358	< 1
TQ0558	Boulevard	1	52.4	8170	251	1.19	1	26	1070	3040	2.3	0.2	144	37	0.36	0.2	587	< 5	36	537	8
TQ0558	Boulevard	2	62.1	4830	181	1.89	1.2	18	1790	1660	3.1	0.3	87	48	0.53	< 0.1	254	< 5	23	743	3
TQ0558	Boulevard	3	59.6	7470	225	1.59	0.9	21	1990	3060	2.5	0.4	130	43	0.39	0.1	472	< 5	32	823	5
TQ0559	Park/Playground	1	166	6150	295	8.35	1.4	23	1740	2160	4.6	0.7	191	28	0.24	0.2	283	< 5	27	2940	< 1
TQ0559	Park/Playground	2	227	5910	279	13.9	1.2	22	2210	2070	6.5	0.9	158	24	0.25	0.3	250	< 5	31	3260	1
TQ0559	Park/Playground	3	117	3600	238	6.34	1.7	12	2180	899	3.8	0.7	159	29	0.31	< 0.1	93	< 5	14	2260	< 1
TQ0560	Park/Playground	1	96.8	10700	326	6.84	1.1	30	1090	4320	3.3	0.4	184	29	0.08	0.3	489	< 5	45	1900	6
TQ0560	Park/Playground	2	104	6480	253	10.9	1.3	20	1360	2600	4.4	0.5	134	32	0.19	0.2	110	< 5	27	2120	2
TQ0560	Park/Playground	3	126	7480	262	10.9	1.4	34	1060	3750	4.2	0.5	125	29	0.19	0.2	407	< 5	34	2360	2
TQ0561	Boulevard	1	128	7380	239	5.33	1.3	25	1220	4100	3.3	0.7	199	60	0.3	0.2	640	< 5	37	1230	4
TQ0561	Boulevard	2	109	7340	231	6.34	1.5	29	1130	3300	3.6	0.6	153	64	0.12	0.2	598	< 5	35	1300	3
TQ0561	Boulevard	3	54.8	12000	368	1.8	0.8	36	1070	5720	1.3	0.2	461	126	0.17	0.3	1170	< 5	55	473	12
TQ0562	Boulevard	1	132	7910	246	10.4	1.3	24	1720	3900	4.5	0.7	168	31	0.19	0.2	698	< 5	38	1490	5
TQ0562	Boulevard	2	129	7370	272	32.5	1.5	37	1250	3850	3.9	0.5	184	31	0.23	0.3	683	< 5	37	1540	6
TQ0562	Boulevard	3	119	7100	218	8.85	1.3	23	1290	3260	4.2	0.6	154	33	0.2	0.2	608	< 5	34	1560	5
TQ0563	Park/Playground	1	56.6	3550	104	2.6	1.6	37	782	2410	1.8	0.3	82	6	0.06	0.1	453	< 5	24	613	< 1
TQ0563	Park/Playground	2	199	4010	208	13	2.6	31	2050	1890	6.8	0.9	97	16	0.28	0.2	203	< 5	22	2610	< 1
TQ0563	Park/Playground	3	120	2890	239	5.9	2.4	28	1350	1430	4.4	0.6	102	21	0.34	0.1	140	< 5	18	1420	< 1
TQ0564	Boulevard	1	125	5120	145	8.75	1.5	19	909	1620	3.8	0.6	129	16	0.15	0.1	399	< 5	25	1280	2
TQ0564	Boulevard	2	111	5950	183	9.21	1	20	910	1980	3.9	0.4	195	27	0.1	0.2	495	< 5	29	1130	3
TQ0564	Boulevard	3	96.3	6310	136	5.9	1.3	19	707	1440	2.8	0.5	124	11	0.04	0.1	386	26	23	944	1
TQ0565	Park/Playground	1	30.4	2360	60	2.6	0.5	13	340	1380	1.2	0.2	53	4	0.06	< 0.1	240	< 5	14	383	< 1
TQ0565	Park/Playground	2	65	3790	118	2.6	2.1	46	674	2320	1.6	0.3	65	14	0.18	0.1	384	< 5	21	669	< 1
TQ0565	Park/Playground	3	57.5	3550	106	7.79	0.8	19	644	2070	2.7	0.3	71	15	0.07	0.1	366	< 5	20	773	1
TQ0566	Park/Playground	1	145	4130	261	5.9	1.6	26	1190	2300	3.3	0.6	89	12	0.02	0.2	300	< 5	21	2310	< 1
TQ0566	Park/Playground	2	65.5	2770	105	2.13	1.4	18	716	1500	1.6	0.4	75	8	0.18	0.1	252	< 5	15	1020	< 1
TQ0566	Park/Playground	3	159	4370	213	6.85	1.5	15	1100	1480	3.9	0.9	278	18	0.26	0.2	268	< 5	18	2070	1
TQ0567	Boulevard	1	243	7560	215	7.32	1.9	19	1410	990	6.2	1.5	1240	32	0.66	0.2	211	< 5	21	3740	< 1
TQ0567	Boulevard	2	143	5400	189	4.73	1.7	25	1300	2070	3.7	0.8	478	14	0.4	0.2	355	< 5	26	1910	1
TQ0567	Boulevard	3	295	7420	194	5.9	2.5	20	1430	1150	7.2	2.1	1440	31	0.97	0.2	184	< 5	22	4790	< 1
TQ0568	Boulevard	1	113	3410	182	4.96	1.3	16	1260	765	2.6	0.5	93	13	0.18	0.2	238	< 5	24	855	< 1
TQ0568	Boulevard	2	74.7	4510	146	6.85	1.4	33	759	1890	1.5	0.3	123	10	0.07	0.1	501	< 5	28	537	< 1
TQ0568	Boulevard	3	132	4110	192	2.6	1.5	32	1040	1500	2	0.4	97	14	0.14	0.1	300	< 5	22	1020	< 1
TQ0569	Vacant Land	1	177	4080	272	8.73	3.1	27	1900	1630	5.3	0.6	160	31	0.28	0.2	177	< 5	14	1220	2
TQ0569	Vacant Land	2	136	4370	201	4.49	2	21	1350	3050	3.9	0.6	97	29	0.19	0.2	330	< 5	21	1240	2
TQ0569	Vacant Land	3	531	5630	235	5.9	1.5	24	1400	2140	3.8	0.5	89	38	0.17	0.2	319	< 5	21	1520	3
TQ0570	Boulevard	1	138	5240	175	5.9	2.4	57	1070	2580	3.6	0.6	135	23	0.18	0.2	408	< 5	29	1530	< 1
TQ0570	Boulevard	2	103	5020	163	8.73	1.5	31	646	2390	3.1	0.4	110	20	0.09	0.2	475	< 5	26	1260	2
TQ0570	Boulevard	3	109	4780	154	7.32	1.3	20	723	2440	3	0.4	108	24	0.12	0.1	418	< 5	24	934	2
TQ0571	Park/Playground	1	41.3	2650	104	3.07	0.5	18	532	1560	1.1	0.2	62	4	0.07	< 0.1	309	< 5	18	766	< 1
TQ0571	Park/Playground	2	85	4170	137	5.43	1.5	36	735	2620	2.4	0.5	78	13	0.08	0.1	455	< 5	25	1460	< 1
TQ0571	Park/Playground	3	104	3390	127	4.49	1.1	20	742	1940	2.7	0.5	64	17	0.06	0.1	277	< 5	19	2010	< 1
TQ0572	Vacant Land (undeveloped)	1	238	3270	233	4.49	2.6	62	521	1320	3.2	0.8	248	51	0.07	0.2	307	< 5	17	1680	< 1
TQ0572	Vacant Land (undeveloped)	2	66.5	1990	81	1.66	0.9	16	256	628	1.2	0.3	41	4	0.04	< 0.1	324	< 5	18	786	< 1
TQ0572	Vacant Land (undeveloped)	3	106	4460	206	2.12	2.1	36	641	1700	1.7	0.4	236	54	0.07	0.1	366	< 5	22	1180	1
TQ0573	Boulevard	1	34.8	11900	272	0.21	0.8	24	1210	1900	0.9	0.1	93	32	0.05	0.1	33	< 5	25	221	3
TQ0573	Boulevard	2	31.4	10100	275	0.15	0.9	28	1040	1970	0.9	0.2	101	27	0.08	0.2	38	< 5	25	328	4
TQ0573	Boulevard	3	35.9	10600	319	0.19	0.8	25	1080	1920	0.9	0.1	1240	32	0.12	0.2	33	< 5	25	278	4
TQ0574	Cemetery	1	43.9	9160	271	0.83	2.5	91	981	4520	1.1	0.2	160	13	0.13	0.2	798	7	44	533	3
TQ0574	Cemetery	2	59.5	9990	292	0.98	1.4	55	940	4450	1.4	0.2	185	19	0.07	0.2	841	< 5	46	694	6
TQ0574	Cemetery	3	50.8	9170	293	0.92	1	29	892	4220	1.4	0.2	172	21	0.18	0.2	744	< 5	43	553	7

Site	Land Use	Vegetation	Rep #	Texture	Moisture (%)	Density (g/cm3)	pH	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe
TQ0575	Park/Playground	sod grasses, forbs	1	S	3.8	1.23	6.1	4620	< 0.1	8.8	23	< 1	4	7	1490	31	4	274	8610
TQ0575	Park/Playground	sod grasses, forbs	2	S/O	15.9	1.11	6.2	5110	0.6	16.9	26	< 1	5	8.5	2150	29	4	307	9120
TQ0575	Park/Playground	sod grasses, forbs	3	S/O	19.1	1.27	6.2	6380	< 0.1	7.6	41	< 1	4	4.5	1550	36	5	212	9480
TQ0576	Park/Playground	sod grasses	1	O	55.3	0.35	5.5	10400	0.6	7.6	61	< 1	8	10.6	5980	64	7	580	14700
TQ0576	Park/Playground	sod grasses	2	O/Cl	41.4	0.57	5.2	12600	0.6	9.1	78	< 1	9	10.8	6830	68	9	641	17800
TQ0576	Park/Playground	sod grasses	3	O/Cl	44.2	0.58	5.1	15100	0.6	11.7	85	< 1	9	11	7190	63	11	577	22500
TQ0577	Boulevard	sod grasses	1	O	24.8	0.47	6	12500	1.4	15.2	81	< 1	11	12.1	7570	155	13	844	23400
TQ0577	Boulevard	sod grasses	2	O	24.6	0.55	5.6	12800	0.8	17.2	83	< 1	11	11.5	10300	55	9	636	17700
TQ0577	Boulevard	sod grasses	3	O	23.1	0.36	5.7	5780	0.6	13.6	62	< 1	9	11.3	19500	29	5	704	9670
TQ0578	Park/Playground	sod grasses, forbs	1	O/Cl	23.0	0.95	6.2	25300	0.5	13.9	140	2	16	6.3	9000	111	15	414	29900
TQ0578	Park/Playground	sod grasses, forbs	2	O/Cl	21.9	0.91	6.1	25800	1	12.3	134	2	18	7.3	7850	174	18	583	36100
TQ0578	Park/Playground	sod grasses, forbs	3	O/Cl	67.9	0.42	6.2	21500	0.7	13.9	116	1	17	9.7	8220	230	17	594	29400
TQ0579	Park/Playground	sod grasses	1	O	58.1	0.28	5.7	5890	0.7	9.4	74	< 1	16	14.6	16500	48	6	692	10400
TQ0579	Park/Playground	sod grasses	2	O	39.3	0.44	5.6	10800	< 0.1	8.2	77	1	14	9.3	15700	32	8	451	14200
TQ0579	Park/Playground	sod grasses	3	O	50.1	0.35	5.1	4480	0.6	8.5	66	< 1	9	14.2	11700	28	5	699	8760
TQ0580	Park/Playground	sod grasses, forbs	1	S/O	16.8	1.07	6	4330	< 0.1	3.1	28	< 1	4	3.5	2290	38	3	149	5850
TQ0580	Park/Playground	sod grasses, forbs	2	S/O	11.9	1.59	6.1	5230	< 0.1	23.6	30	< 1	4	2.3	1550	75	4	128	7830
TQ0580	Park/Playground	sod grasses, forbs	3	S/Si/O	5.9	1.28	6.2	4110	< 0.1	2.7	27	< 1	3	2.9	1850	26	3	127	6080
TQ0581	Cemetery	sod grasses, forbs	1	Cl	26.9	1.33	7.1	36600	< 0.1	6.3	202	3	14	2.6	6360	89	17	127	41300
TQ0581	Cemetery	sod grasses, forbs	2	S	11.4	0.89	7	31300	< 0.1	10.2	161	2	15	6	5110	128	20	295	40300
TQ0581	Cemetery	sod grasses, forbs	3	Cl	28.9	1.51	7.4	34900	< 0.1	6.2	183	3	16	2.9	7330	93	17	114	39900
TQ0582	Vacant Land	sod grasses, forbs	1	O/S	37.2	0.60	5.4	15600	2.7	52.6	100	1	7	20.8	5190	42	12	881	22600
TQ0582	Vacant Land	sod grasses, forbs	2	S/Cl/O	18.7	1.12	5.6	17300	1	29.6	73	1	8	9.7	2780	49	13	456	22500
TQ0582	Vacant Land	sod grasses, forbs	3	S/O	12.8	0.87	5.8	17200	1	25.8	64	1	7	9.3	2440	51	14	513	24200
TQ0583	Boulevard	native and weedy grasses	1	O	39.0	1.11	6.2	16700	< 0.1	7.1	102	1	10	4.3	8090	57	8	133	17200
TQ0583	Boulevard	native and weedy grasses	2	O	34.7	0.66	6.1	10800	< 0.1	7.9	63	< 1	7	4.4	5560	49	6	149	13100
TQ0583	Boulevard	native and weedy grasses	3	O	37.1	0.85	5.7	12900	< 0.1	7.3	73	< 1	9	3.5	6420	48	6	125	13700
TQ0584	Boulevard	sod grasses, forbs	1	O	43.5	0.58	6.4	19200	1.4	24	122	1	20	17.4	8890	60	13	594	26100
TQ0584	Boulevard	sod grasses, forbs	2	O	41.2	0.44	6.5	20700	1.1	25.7	100	1	19	14.1	7610	70	14	664	28200
TQ0584	Boulevard	sod grasses, forbs	3	O/Si	55.8	0.61	6.9	9660	1.1	23.5	50	< 1	27	18.2	9110	50	9	570	15900
TQ0585	Park/Playground	sod grasses, forbs	1	S/O/Cl	33.3	0.94	5.8	4730	< 0.1	4.9	28	< 1	7	4.7	1930	22	3	202	8010
TQ0585	Park/Playground	sod grasses, forbs	2	S/O	39.6	0.81	6.5	3810	< 0.1	5.8	26	< 1	10	5	3520	19	3	181	6320
TQ0585	Park/Playground	sod grasses, forbs	3	S/O	13.4	0.73	5.9	7710	< 0.1	5	59	< 1	5	4.4	1930	174	6	225	12500
TQ0586	Park/Playground	sod grasses, forbs	1	S/O	3.6	0.77	6.8	10400	< 0.1	6.1	64	< 1	8	5.4	4000	128	8	214	16700
TQ0586	Park/Playground	sod grasses, forbs	2	O/S	51.7	0.39	5.9	9650	1.5	20.8	83	< 1	20	26.1	11600	106	9	775	15600
TQ0586	Park/Playground	sod grasses, forbs	3	S/O/Si	11.2	1.21	6.5	10300	< 0.1	5.8	68	< 1	7	5.8	3250	245	9	226	16400
TQ0587	Park/Playground	sod grasses	1	O	22.8	0.65	6.5	6340	0.6	15.9	59	< 1	4	8.1	5800	77	7	801	12600
TQ0587	Park/Playground	sod grasses	2	O/S	38.7	0.69	6.5	6470	0.7	18.9	59	< 1	5	9.1	11400	106	26	921	18300
TQ0587	Park/Playground	sod grasses	3	O/Cl	38.7	0.83	6.8	21900	1.3	33.8	139	< 1	8	13.4	10200	81	19	1270	35000
TQ0588	Park/Playground	sod grasses, forbs	1	O/S	38.9	0.83	7	8900	< 0.1	8.5	75	< 1	9	4.8	5970	72	7	410	13500
TQ0588	Park/Playground	sod grasses, forbs	2	O/S	54.1	0.52	6.9	4710	0.7	11.7	66	< 1	15	10.8	12400	69	4	798	8060
TQ0588	Park/Playground	sod grasses, forbs	3	O/S	64.2	0.40	6.9	7030	0.9	15.3	92	< 1	20	14.7	10400	70	9	1110	12900
TQ0589	School yard	sod grasses, forbs	1	O/Si	22.9	0.79	6.4	4550	< 0.1	6.2	63	< 1	5	4	12800	41	5	259	7540
TQ0589	School yard	sod grasses, forbs	2	S	3.1	1.53	6.7	3900	< 0.1	3.5	34	< 1	3	2	1320	124	3	124	6530
TQ0589	School yard	sod grasses, forbs	3	O/Si	32.1	0.55	6	3620	< 0.1	8.7	58	< 1	6	6.4	11300	53	4	437	6870
TQ0590	Vacant Land	native and weedy grasses and shrubs	1	S/O	11.0	1.16	7.3	13700	1.2	14.7	105	< 1	6	7.8	7030	63	12	326	22500
TQ0590	Vacant Land	native and weedy grasses and shrubs	2	O/Si	19.4	0.72	7	18100	4	36.9	136	< 1	10	23.3	17200	66	14	798	27100
TQ0590	Vacant Land	native and weedy grasses and shrubs	3	S/O	16.0	1.22	7.5	35800	4.3	13	214	< 1	10	7.7	10200	80	16	297	32800
TQ0591	Boulevard	weedy grasses, forbs	1	O/Si/Cl	19.0	1.30	7.3	28700	< 0.1	7.2	166	< 1	10	3.5	9090	73	12	188	25700
TQ0591	Boulevard	weedy grasses, forbs	2	O/Si	12.3	0.68	7	6180	< 0.1	7.3	43	< 1	5	2.3	7380	40	4	150	9200
TQ0591	Boulevard	weedy grasses, forbs	3	O/Si	16.2	0.69	6.8	8970	0.6	13.3	68	< 1	8	11.4	12200	94	7	608	13300

Site	Land Use	Rep #	Pb	Mg	Mn	Hg	Mo	Ni	P	K	Se	Ag	Na	Sr	S (%)	Tl	Ti	Sn	V	Zn	Zr
TQ0575	Park/Playground	1	57.9	2580	105	2.9	0.5	13	583	1190	1.6	0.3	55	4	0.17	< 0.1	210	< 5	14	1140	< 1
TQ0575	Park/Playground	2	62.6	3020	121	4.49	0.4	13	642	1240	2.5	0.4	63	6	0.14	< 0.1	232	< 5	17	1950	< 1
TQ0575	Park/Playground	3	34.8	3700	113	2.6	0.4	16	590	2040	1.3	0.2	85	4	0.03	< 0.1	343	< 5	22	577	< 1
TQ0576	Park/Playground	1	69.8	5760	262	4.96	1.5	26	2400	2730	2.8	0.4	218	14	0.2	0.2	480	< 5	32	701	2
TQ0576	Park/Playground	2	75.9	6300	285	4.02	1.5	31	2220	2600	3.1	0.4	148	14	0.18	0.2	581	< 5	36	904	4
TQ0576	Park/Playground	3	67.9	7320	305	4.02	1.3	32	2570	3310	3.3	0.3	169	15	0.23	0.2	621	39	41	948	5
TQ0577	Boulevard	1	88.9	7530	263	5.43	2.2	60	1170	3440	3.4	0.5	174	22	0.12	0.2	601	< 5	39	1690	4
TQ0577	Boulevard	2	87.3	7220	307	5.67	1.1	28	1080	3160	3.2	0.4	140	26	0.17	0.2	632	< 5	39	1180	5
TQ0577	Boulevard	3	79.5	4410	288	2.6	1.2	14	1160	1480	2.3	0.5	76	39	0.35	0.1	282	< 5	20	657	2
TQ0578	Park/Playground	1	60.3	11600	464	2.13	1.3	52	945	6110	1.7	0.3	230	21	0.07	0.3	1040	< 5	60	845	9
TQ0578	Park/Playground	2	65.6	12800	477	3.54	3.1	73	1410	6560	2	0.3	293	17	0.06	0.3	1120	< 5	65	997	9
TQ0578	Park/Playground	3	72.8	11200	463	5.9	2.8	90	1260	5650	2.6	0.4	237	18	0.11	0.2	918	< 5	56	961	8
TQ0579	Park/Playground	1	72.8	4310	723	2.6	1.7	24	3290	2180	2.9	0.4	82	30	0.42	0.1	97	< 5	21	553	1
TQ0579	Park/Playground	2	45	5140	641	2.13	1.2	23	3560	3340	2.3	0.2	62	31	0.49	0.1	136	< 5	30	406	3
TQ0579	Park/Playground	3	74	2940	495	2.13	1.6	17	2720	1590	2.6	0.3	50	23	0.58	0.1	81	< 5	18	583	< 1
TQ0580	Park/Playground	1	19.4	2530	130	1.19	0.7	15	617	1840	0.4	< 0.1	78	5	0.08	< 0.1	252	< 5	15	134	< 1
TQ0580	Park/Playground	2	28.1	2900	118	0.24	0.9	29	530	1600	0.4	< 0.1	88	4	0.04	< 0.1	316	< 5	20	136	< 1
TQ0580	Park/Playground	3	17.4	2500	114	0.43	0.3	10	550	1440	0.3	< 0.1	74	4	0.05	< 0.1	246	< 5	16	114	< 1
TQ0581	Cemetery	1	27.3	18800	600	0.43	0.2	43	814	8730	0.6	< 0.1	530	19	0.06	0.4	1650	< 5	85	186	18
TQ0581	Cemetery	2	42.8	15700	625	1.18	0.8	55	922	8750	1	0.2	374	15	0.04	0.3	1350	< 5	76	583	12
TQ0581	Cemetery	3	22.3	19100	641	0.33	0.2	43	854	8210	0.5	< 0.1	526	19	0.04	0.4	1510	< 5	83	235	16
TQ0582	Vacant Land	1	374	7530	508	3.72	0.9	22	1500	3270	5.2	1.1	141	19	0.08	0.4	656	< 5	45	3490	3
TQ0582	Vacant Land	2	136	8510	547	3.92	0.7	25	1390	3670	2.7	0.5	194	11	0.06	0.2	853	< 5	51	1820	3
TQ0582	Vacant Land	3	119	8860	598	4.67	0.7	22	1290	4080	2.8	0.5	197	10	0.07	0.2	840	< 5	51	1730	4
TQ0583	Boulevard	1	30.7	8180	175	0.33	0.5	27	1030	3200	1.2	0.1	200	39	0.08	0.2	799	< 5	47	214	7
TQ0583	Boulevard	2	30.8	5910	132	0.52	0.5	21	922	2710	1	0.1	125	27	0.12	< 0.1	539	< 5	34	205	3
TQ0583	Boulevard	3	29.1	5940	130	0.24	0.5	23	854	2490	1	0.1	127	33	0.15	0.1	609	< 5	37	188	5
TQ0584	Boulevard	1	163	10400	520	6.18	0.9	28	1540	5630	3.8	0.7	284	30	0.18	0.2	813	< 5	50	2900	5
TQ0584	Boulevard	2	143	12400	550	5.14	1.1	33	1410	5720	3.6	0.6	362	19	0.19	0.2	906	< 5	59	2290	4
TQ0584	Boulevard	3	118	7880	368	4.67	0.8	21	1340	1840	3.8	0.6	1020	29	0.17	0.1	400	< 5	31	3710	1
TQ0585	Park/Playground	1	39.3	2650	65	2.12	0.3	8	939	1510	1.4	0.2	90	8	0.04	< 0.1	199	< 5	18	707	< 1
TQ0585	Park/Playground	2	27.3	2640	95	0.99	0.3	8	832	538	1	0.1	139	24	0.06	< 0.1	182	< 5	15	439	< 1
TQ0585	Park/Playground	3	29.7	4900	143	0.52	2	71	736	3340	0.8	0.1	124	11	0.03	< 0.1	528	< 5	29	238	< 1
TQ0586	Park/Playground	1	37.8	6680	213	0.71	1.4	55	1080	3540	0.7	0.1	142	7	0.08	< 0.1	599	< 5	39	276	< 1
TQ0586	Park/Playground	2	169	6210	340	5.33	2.3	45	2540	3120	6	0.8	155	28	0.17	0.2	233	< 5	28	4340	< 1
TQ0586	Park/Playground	3	49.1	6630	210	2.88	2.5	93	961	3660	1.4	0.2	185	7	0.08	0.1	555	< 5	36	560	< 1
TQ0587	Park/Playground	1	88.4	4600	153	17.2	2.1	37	539	1890	4.6	0.7	82	12	0.12	0.1	375	< 5	24	743	< 1
TQ0587	Park/Playground	2	98.9	7150	186	4.96	3.5	90	469	1670	3.7	0.6	220	20	0.16	0.1	321	< 5	24	742	2
TQ0587	Park/Playground	3	193	15100	604	7.88	4.2	44	627	4210	4.6	0.9	239	21	0.14	0.4	1130	< 5	75	1620	7
TQ0588	Park/Playground	1	46.2	5760	288	3.73	1	36	534	2170	2	0.2	163	16	0.09	0.2	488	< 5	26	617	3
TQ0588	Park/Playground	2	90.1	4580	110	7.5	1.6	36	779	1180	4.3	0.6	166	36	0.2	0.1	252	< 5	17	1040	1
TQ0588	Park/Playground	3	138	6340	486	25.7	2.2	36	981	1460	5.4	0.8	248	28	0.15	0.2	264	< 5	26	1610	< 1
TQ0589	School yard	1	30.3	4000	127	3.07	1.3	23	587	1420	1.5	0.2	70	33	0.04	< 0.1	233	< 5	15	421	2
TQ0589	School yard	2	16.7	2430	82	0.24	1.8	59	265	1270	0.2	< 0.1	59	3	0.25	< 0.1	276	< 5	15	105	< 1
TQ0589	School yard	3	50.1	3150	191	3.63	1.8	28	800	1290	2.2	0.3	47	28	0.06	< 0.1	189	< 5	14	785	2
TQ0590	Vacant Land	1	83.9	9070	277	3.45	0.8	37	475	4120	1.8	0.3	178	13	0.05	0.3	807	< 5	42	1160	6
TQ0590	Vacant Land	2	409	10500	417	20.1	0.9	39	732	5450	5.5	0.8	237	26	0.14	0.4	899	< 5	50	5930	8
TQ0590	Vacant Land	3	160	17100	496	1.47	0.4	47	633	7970	1.3	0.2	354	17	0.03	0.5	1400	< 5	72	838	16
TQ0591	Boulevard	1	36.4	14900	368	1.56	0.5	39	545	6270	0.8	0.2	326	15	0.05	0.4	1240	< 5	60	413	13
TQ0591	Boulevard	2	27.1	4860	118	1.37	0.8	20	360	1460	0.9	0.1	99	12	0.04	< 0.1	332	< 5	21	206	2
TQ0591	Boulevard	3	91.1	9640	201	4.86	2	44	661	2430	2.7	0.5	116	14	0.13	0.2	444	< 5	27	742	2

Site	Land Use	Vegetation	Rep #	Texture	Moisture (%)	Density (g/cm3)	pH	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe
TQ0592	Park/Playground	native and weedy grasses and shrubs	1	O	58.7	0.30	5.8	5480	1.1	30.6	76	< 1	9	13	17400	44	6	1350	8580
TQ0592	Park/Playground	native and weedy grasses and shrubs	2	O	57.8	0.30	5.9	4910	1.5	48.3	64	< 1	9	17.8	15800	23	7	2280	11200
TQ0592	Park/Playground	native and weedy grasses and shrubs	3	O	36.5	0.53	5.8	7550	1.5	49.2	75	< 1	7	15.3	8330	33	10	2220	16300
TQ0593	School yard	none (sand)	1	S	0.8	1.51	7.1	3340	< 0.1	2.4	21	< 1	2	0.8	1010	37	2	68	4860
TQ0593	School yard	none (sand)	2	S	0.6	1.74	7.2	3640	< 0.1	2.5	23	< 1	2	0.7	1060	31	2	49	5290
TQ0593	School yard	none (sand)	3	S	0.5	1.62	7	3110	< 0.1	2.5	19	< 1	2	0.7	1210	25	2	54	4680
Creighton Sites																			
TQ0594	Vacant Land (undeveloped)	native grasses and shrubs	1	S/Si/O	15.0	1.11	6.5	4980	2.2	97.8	34	< 1	3	8.4	10400	33	6	544	17300
TQ0594	Vacant Land (undeveloped)	native grasses and shrubs	2	S/Si/O	15.1	1.01	6	7220	3.8	158	54	< 1	4	8.2	22000	44	6	759	23000
TQ0594	Vacant Land (undeveloped)	native grasses and shrubs	3	S/Si	7.9	1.68	7	4490	2	91.4	37	< 1	5	8.1	41800	42	5	398	17300
TQ0595	Park/Playground	sod grasses	1	O	43.7	0.45	5.3	2720	1.5	68.7	25	< 1	3	11.8	4250	15	7	635	10900
TQ0595	Park/Playground	sod grasses	2	O	46.1	0.48	5.1	2510	1.1	52.5	25	< 1	4	10.9	8710	13	6	570	8480
TQ0595	Park/Playground	sod grasses	3	O	43.7	0.41	5	3420	2	68.6	36	< 1	4	10.5	5510	15	8	655	11700
TQ0596	Boulevard	sod grasses	1	O/Cl	38.4	0.71	5.4	7160	2.1	104	60	< 1	3	10.3	5160	27	11	661	19100
TQ0596	Boulevard	sod grasses	2	O	39.1	0.55	4.2	5920	2.4	129	50	< 1	3	9.3	5660	23	12	707	21500
TQ0596	Boulevard	sod grasses	3	O	43.3	0.35	4.6	3470	2.1	102	44	< 1	2	13	7190	15	11	794	15700
TQ0597	Vacant Land	weedy grasses, forbs	1	S/Gr/O	6.6	1.22	6.7	6910	0.6	43.6	47	< 1	3	5	11100	202	9	300	14600
TQ0597	Vacant Land	weedy grasses, forbs	2	S/Gr/O	9.9	1.02	4.8	6780	1.3	97.6	50	< 1	2	3	3820	204	9	307	18400
TQ0597	Vacant Land	weedy grasses, forbs	3	S/Gr/O	8.2	1.02	5.3	6200	< 0.1	31.1	45	< 1	2	1.1	4640	171	6	248	12100
TQ0598	School yard	sod grasses	1	O/S	24.5	0.79	5.1	3880	0.7	23.6	37	< 1	3	9	2340	35	5	438	9010
TQ0598	School yard	sod grasses	2	O/S	13.4	0.89	5.8	3790	< 0.1	16.8	35	< 1	3	6.1	2110	19	4	267	7030
TQ0598	School yard	sod grasses	3	O	47.5	0.40	5	2470	0.7	25.4	31	< 1	3	10.9	4750	20	4	531	7300
TQ0599	Boulevard	weedy grasses, forbs	1	S/Si	6.5	1.44	6.1	8170	< 0.1	24.3	49	< 1	3	5.4	2740	39	7	346	13500
TQ0599	Boulevard	weedy grasses, forbs	2	S	5.4	1.77	6.4	5480	< 0.1	24.4	25	< 1	4	2.6	2230	27	6	337	10800
TQ0599	Boulevard	weedy grasses, forbs	3	S/Si	18.6	1.20	5.9	7110	0.5	35.8	40	< 1	3	5	1990	50	8	561	15100
TQ0600	Park/Playground	sod grasses, forbs	1	S	6.6	1.71	5.6	3890	< 0.1	4.3	29	< 1	2	1	1140	44	3	78	6850
TQ0600	Park/Playground	sod grasses, forbs	2	S	8.9	1.59	6.1	2880	< 0.1	5.2	22	< 1	1	1.3	904	14	2	94	4650
TQ0600	Park/Playground	sod grasses, forbs	3	S/Si	15.6	1.01	6.7	3760	< 0.1	15.9	31	< 1	2	6.2	3060	30	4	270	6800
TQ0601	Residence	sod grasses	1	O	61.6	0.32	6.4	4480	1.3	41.5	62	< 1	12	17.8	18100	27	6	826	9080
TQ0601	Residence	sod grasses	2	O	64.2	0.18	6.1	5130	1.8	66	72	< 1	12	29.5	17100	21	7	1200	11900
TQ0601	Residence	sod grasses	3	O	60.8	0.35	6	4710	1.1	40.7	61	< 1	8	15.1	15400	37	6	671	9610
TQ0602	Park/Playground	sod grasses, forbs	1	S	3.7	1.54	6.2	3090	< 0.1	4.3	20	< 1	1	1.8	795	15	2	88	4960
TQ0602	Park/Playground	sod grasses, forbs	2	S/Si	8.5	1.09	5.9	3480	< 0.1	6.8	25	<*1	1	3.4	1070	17	2	137	5670
TQ0602	Park/Playground	sod grasses, forbs	3	S	9.0	1.50	6.9	3500	< 0.1	5.2	23	< 1	2	1.6	1200	19	2	101	5900
TQ0603	Park/Playground	sod grasses, forbs	1	S	5.0	1.30	6	3110	< 0.1	3.4	25	< 1	< 1	2.8	830	18	2	100	5050
TQ0603	Park/Playground	sod grasses, forbs	2	S	4.5	1.63	6.3	3470	< 0.1	3.7	26	< 1	1	1.8	1320	31	2	84	5280
TQ0603	Park/Playground	sod grasses, forbs	3	S	4.2	1.68	6.3	3170	< 0.1	4.6	22	< 1	1	1.8	1120	32	2	100	5870
TQ0604	Park/Playground	sod grasses, forbs	1	S	12.0	1.73	6.3	3120	< 0.1	2	25	< 1	2	1	1200	24	2	44	5310
TQ0604	Park/Playground	sod grasses, forbs	2	S	6.6	1.68	6.6	3490	< 0.1	2.6	30	< 1	2	1	1180	37	3	61	6090
TQ0604	Park/Playground	sod grasses, forbs	3	S	3.6	1.60	6.5	3190	< 0.1	2.3	27	< 1	1	0.8	1030	30	2	59	5750
TQ0605	Boulevard	sod grasses, forbs	1	O	60.8	0.32	5.6	3650	0.5	10.5	57	< 1	7	13.1	15100	36	4	456	6910
TQ0605	Boulevard	sod grasses, forbs	2	O	61.5	0.30	5.6	2550	< 0.1	14	43	< 1	6	10.7	10500	24	3	357	4860
TQ0605	Boulevard	sod grasses, forbs	3	O	56.3	0.35	5.6	4460	0.5	12.4	57	< 1	8	13	13000	36	4	427	6910
TQ0606	Residence	vegetable garden, sod grasses	1	O	38.8	0.55	4.5	7960	3	139	73	< 1	4	9.6	9780	42	13	732	25400
TQ0606	Residence	vegetable garden, sod grasses	2	O	25.5	0.78	6.4	12800	1.8	81.8	172	< 1	9	9.8	11800	38	13	541	22600
TQ0606	Residence	vegetable garden, sod grasses	3	O/Si	19.2	1.06	7	9130	1	41.1	115	< 1	9	4.6	12000	31	8	242	14800
TQ0607	Park/Playground Bakers Narrows	sod grasses	1	O/Si	27.0	0.63	7.3	9140	< 0.1	5.8	134	< 1	7	1.1	25000	27	7	54	14900
			2	O/Cl	29.7	0.85	7.4	8450	< 0.1	5.8	118	< 1	8	1.3	21900	23	7	84	13700
			3	O	27.9	0.57	6.6	8990	< 0.1	6.6	56	< 1	7	1.8	7980	29	6	133	12100
TQ0608	Park/Playground Cranberry Portage	sod grasses, forbs	1	Si/Cl	17.1	1.16	7.4	13800	< 0.1	2.6	62	< 1	10	< 0.2	9700	47	8	28	16800
			2	O/Si	23.0	0.87	7.5	6830	< 0.1	1.9	36	< 1	7	< 0.2	8750	24	4	16	9640
			3	Si/Cl	19.7	1.17	7.6	15800	< 0.1	2.9	80	< 1	9	< 0.2	10100	56	10	33	20500

Site	Land Use	Rep #	Pb	Mg	Mn	Hg	Mo	Ni	P	K	Se	Ag	Na	Sr	S (%)	Tl	Ti	Sn	V	Zn	Zr
TQ0592	Park/Playground	1	96.8	4640	135	26.2	2.9	24	438	1110	5.7	0.9	60	26	0.37	0.2	317	< 5	17	1500	3
TQ0592	Park/Playground	2	144	3950	138	26.2	4	15	499	896	10.3	1.5	63	25	0.64	0.2	192	< 5	14	2120	3
TQ0592	Park/Playground	3	151	4460	187	29.5	4.5	20	412	1510	8.2	1.5	101	18	0.47	0.2	379	< 5	22	2300	4
TQ0593	School yard	1	5.3	2210	53	0.24	0.4	18	284	924	< 0.2	< 0.1	45	2	0.04	< 0.1	202	< 5	11	44	< 1
TQ0593	School yard	2	4.7	2170	58	0.14	0.3	14	277	949	< 0.2	< 0.1	50	3	0.02	< 0.1	209	< 5	12	38	1
TQ0593	School yard	3	4.9	2170	53	0.14	0.3	12	256	797	< 0.2	< 0.1	40	2	0.04	< 0.1	196	< 5	10	35	1
Creighton Sites																					
TQ0594	Vacant Land (undeveloped)	1	209	8530	100	4.5	1.4	15	212	710	4.9	1	101	8	0.3	0.3	301	< 5	21	787	< 1
TQ0594	Vacant Land (undeveloped)	2	356	17600	125	8.6	1.8	19	563	977	8.3	2	136	10	0.19	0.4	402	< 5	29	869	< 1
TQ0594	Vacant Land (undeveloped)	3	185	28900	131	5.9	1.7	17	285	725	5	0.9	115	13	0.17	0.2	292	< 5	20	612	< 1
TQ0595	Park/Playground	1	130	2360	152	4.5	2.2	7	1260	973	4.6	0.8	35	8	0.64	0.2	118	< 5	9	530	< 1
TQ0595	Park/Playground	2	107	1970	113	4.1	1.6	6	1260	1080	3.7	0.7	39	10	0.65	0.1	94	< 5	9	482	< 1
TQ0595	Park/Playground	3	122	2690	191	3.6	2.1	9	1270	1360	4.2	0.8	43	13	0.89	0.2	155	< 5	12	606	< 1
TQ0596	Boulevard	1	163	4160	178	16.3	1.4	13	1640	1110	6.9	1	73	10	0.49	0.3	276	< 5	22	824	< 1
TQ0596	Boulevard	2	186	4060	190	18.5	1.8	11	1670	1340	8	1.1	61	8	0.63	0.3	223	< 5	20	755	< 1
TQ0596	Boulevard	3	177	3460	163	9	1.4	7	1870	1070	6.6	1.1	39	9	0.65	0.3	148	< 5	12	696	< 1
TQ0597	Vacant Land	1	60	8690	236	1.1	3.4	84	545	1910	1.9	0.4	85	9	0.35	0.2	365	< 5	26	327	< 1
TQ0597	Vacant Land	2	114	6290	119	4.1	4.2	86	501	2110	4.2	0.7	100	4	0.67	0.3	378	< 5	25	274	< 1
TQ0597	Vacant Land	3	52.5	5990	95	0.7	3.1	75	410	1880	1.3	0.4	94	4	0.11	0.1	393	< 5	24	146	1
TQ0598	School yard	1	83.6	2520	108	1.5	1.3	15	1180	913	2.1	0.4	44	5	0.12	0.1	166	< 5	15	293	< 1
TQ0598	School yard	2	52.8	2360	108	1	0.7	9	750	1070	1.2	0.2	45	5	0.11	0.1	201	< 5	13	216	< 1
TQ0598	School yard	3	96.4	2860	124	2.5	1.5	9	1210	698	2.5	0.5	36	6	0.29	0.1	113	< 5	10	357	< 1
TQ0599	Boulevard	1	56.6	4210	300	1	0.8	18	491	1760	2.1	0.4	79	5	0.14	0.2	389	< 5	25	533	1
TQ0599	Boulevard	2	49.5	3270	108	1.2	0.7	12	402	1020	2.2	0.3	58	3	0.25	0.1	257	< 5	19	447	< 1
TQ0599	Boulevard	3	62.5	3990	133	3.5	1	22	473	1630	3.9	0.8	79	4	0.54	0.2	363	< 5	23	992	< 1
TQ0600	Park/Playground	1	8.8	1940	61	0.6	0.6	18	456	1180	0.3	< 0.1	59	3	0.02	< 0.1	270	< 5	18	56	1
TQ0600	Park/Playground	2	13.3	1430	41	0.2	0.2	7	329	835	0.3	< 0.1	47	2	0.04	< 0.1	193	< 5	11	52	< 1
TQ0600	Park/Playground	3	47.8	2930	66	2.5	0.7	14	405	1310	1.4	0.2	54	4	0.06	< 0.1	242	< 5	14	246	< 1
TQ0601	Residence	1	129	3450	348	8.6	1.6	13	1540	769	5	0.7	103	28	0.42	0.2	139	< 5	15	999	< 1
TQ0601	Residence	2	201	3770	412	7.2	2.2	13	1860	1280	6.4	1	126	30	0.34	0.2	161	< 5	16	1290	1
TQ0601	Residence	3	110	3010	496	4.9	1.8	18	1220	847	3.8	0.6	144	22	0.18	0.2	184	< 5	16	882	< 1
TQ0602	Park/Playground	1	16.1	1600	45	0.07	0.3	6	299	801	0.2	< 0.1	38	2	0.03	< 0.1	187	< 5	11	50	< 1
TQ0602	Park/Playground	2	29.9	1790	60	0.23	0.3	8	374	1040	0.4	0.1	43	3	0.02	< 0.1	218	< 5	13	151	< 1
TQ0602	Park/Playground	3	14.8	1700	59	0.38	0.2	8	402	854	0.4	< 0.1	49	7	0.05	< 0.1	215	< 5	14	63	< 1
TQ0603	Park/Playground	1	19.1	1740	50	0.08	0.3	8	295	1020	< 0.2	< 0.1	41	2	0.06	< 0.1	202	< 5	12	61	< 1
TQ0603	Park/Playground	2	17.3	1960	46	0.08	0.4	14	339	1080	0.2	< 0.1	50	3	0.03	< 0.1	225	< 5	13	52	< 1
TQ0603	Park/Playground	3	16.4	1640	50	0.08	0.5	14	435	934	0.2	< 0.1	47	2	0.05	< 0.1	207	< 5	14	51	< 1
TQ0604	Park/Playground	1	5.8	1640	49	0.05	0.3	10	375	1020	< 0.2	< 0.1	64	3	0.02	< 0.1	217	< 5	13	89	< 1
TQ0604	Park/Playground	2	6.5	1850	57	0.08	0.4	16	419	1190	< 0.2	< 0.1	64	3	0.03	< 0.1	253	< 5	15	76	< 1
TQ0604	Park/Playground	3	6.5	1690	54	0.05	0.3	13	399	1130	< 0.2	< 0.1	50	3	0.06	< 0.1	228	< 5	14	32	< 1
TQ0605	Boulevard	1	72.9	3030	266	6.8	1.5	18	1210	1050	1.7	0.3	56	32	0.42	0.1	190	< 5	15	359	1
TQ0605	Boulevard	2	78.3	2130	215	0.69	1.2	12	1030	751	1.5	0.3	35	30	0.35	< 0.1	117	< 5	11	304	1
TQ0605	Boulevard	3	71	3170	262	0.95	1.4	17	1560	1380	1.7	0.4	53	32	0.33	0.1	200	< 5	17	357	< 1
TQ0606	Residence	1	203	4770	198	11	1.7	17	3080	1190	8.9	1.4	69	10	0.41	0.4	228	< 5	29	695	< 1
TQ0606	Residence	2	196	7150	282	4.9	1.1	21	1640	2910	4.3	4.1	117	25	0.35	0.4	370	15	32	1100	3
TQ0606	Residence	3	80.2	5490	241	3.2	0.6	17	1420	1890	2.6	2.1	89	23	0.13	0.2	287	10	25	858	2
TQ0607	Park/Playground Bakers Narrows	1	15.3	11100	362	0.24	0.7	24	942	1700	0.6	< 0.1	74	30	0.08	0.1	28	< 5	22	128	5
		2	19.5	10400	299	0.24	0.5	20	868	1750	0.7	< 0.1	93	29	0.14	0.1	89	< 5	23	222	4
		3	31	6380	197	0.33	0.5	15	862	1990	0.7	< 0.1	145	15	0.1	< 0.1	409	< 5	26	379	3
TQ0608	Park/Playground Cranberry Portage	1	4.9	12100	217	0.14	0.2	25	929	2380	0.2	< 0.1	168	9	0.04	0.1	523	< 5	42	40	4
		2	6.3	5640	127	0.14	0.1	14	709	868	0.2	< 0.1	100	11	0.07	< 0.1	220	< 5	22	31	1
		3	4.7	13700	238	0.14	0.2	34	787	2780	0.2	< 0.1	206	10	0.04	0.1	621	< 5	49	46	6